

GATES

The plant associations of the
Recent & Fossil beaches of
Lake Michigan, between Kenosha,
Wisconsin & Waukegan, Illinois

Botany

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The Plant Associations of the Recent and Fossil
Beaches of Lake Michigan, between
Kenosha, Wisconsin and Waukegan,
Illinois

BY

FRANK C. GATES

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FOR THE

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IN

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IN THE

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Frank C. Gates

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Beaches of Lake Michigan, between Kenosha, Wisconsin and
Waukegan, Illinois

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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in General Science


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TABLE OF CONTENTS.

Table of Contents.

Illustrations.

Introduction - - - - -	1.
Description of the Region- - - - -	3.
History of the region since glacial times- - - - -	4.
Climate- - - - -	6.
Edafic factors - - - - -	7.
Influence of Lake Michigan - - - - -	8.
General description of the region -- - - -	8.

Associations.

General discussion- - - - -	12.
-----------------------------	-----

The Beach Associations

The Chlamydomonas Association- - - - -	16.
The Cakile-Xanthium Association- - - - -	21.
The Triglochin palustris Association - - - - -	26.
The Juncus balticus littoralis Association - - - - -	27.
The Potentilla anserina Association- - - - -	31.

The Dune Associations.

General discussion - - - - -	35.
The Calamovilfa dune - - - - -	38.
The Ammophila dune - - - - -	41.
The Salix syrticola dune - - - - -	43.
The Prunus pumila dune - - - - -	44.
The Populus candicans dune - - - - -	45.
The Elymus canadensis dune - - - - -	46.
The Juniperus dunes- - - - -	47.

Miscellaneous dunes

The Populus-Salix dune - - - - -	49.
The Salix glaucophylla dune- - - - -	50.
The Panicum virgatum dune- - - - -	51.
The Andropogon scoparius dune- - - - -	51.
The Populus-Salix-Cornus thicket dune - - - - -	52.
The Betula alba papyrifera dune- - - - -	52.
The relic dunes- - - - -	53.
The man-made dune- - - - -	55.
The travelling dune- - - - -	57.

The Upper Beach Associations.

The Artemisia-Panicum Association- - - - -	58.
The Bunchgrass Association, Andropogon scoparius consociates - - - - -	62.
Sporobolus heterolepis-	
Sorghastrum nutans consociates - - - - -	69.
The Arctostaphylos-Juniperus heath Association - - - - -	71.
The Pine Forest Association - - - - -	75.
The Quercus velutina Association - - - - -	79.
The Blowout association- - - - -	85.

Brief Bibliography of the more important works consulted- - - - -	89.
---	-----

List of species in systematic order- - - - -	90.
--	-----

ILLUSTRATIONS.

Fig. 1.	Map, showing the Plant Provinces in United States - - -	1a
"	2. Topographic Map of the Waukegan-Kenosha Area - - - - -	3a
"	3. Temperatur curvs for Chicago and Milwaukee- - - - -	6a
"	4. Precipitation (rain) curvs " " - - - - -	6b
"	5. Precipitation (snow), sunshine and wind curvs. - - - - -	6c
"	6. Fluctuations of Lake Michigan Level since 1854- - - - -	8a
"	7. Blowout in <i>Quercus velutina</i> association near Kenosha- -	10
"	8. End of an Oak Ridge - - - - -	11
"	9. Profiles of types of lower beaches- - - - -	17
"	10. Beach pool- - - - -	18
"	11. Little dune formd by <i>Euphorbia polygonifolia</i> - - - - -	23
"	12. Growth habit of <i>Juncus balticus littoralis</i> - - - - -	27
"	13. Relic Dunes formd by <i>Juncus balticus littoralis</i> and <i>Juniperus nana</i> <i>complanatus depressus</i> - - - - -	29
"	14. Profile of the beach near Kenosha, Wisconsin - - - - -	30
"	15. Curvs showing variations in hight and abundance of <i>Potentilla anserina</i> in three adjoining associations- -	32
"	16. Profile of original beach at Kenosha, Wisconsin - - - - -	34
"	17. Washt-away beach near Camp Logan, showing the exposd roots of <i>Calamovilfa longifolia</i> - - - - -	38
"	18. <i>Calamovilfa</i> dune- - - - -	39
"	19. <i>Ammophila</i> dune- - - - -	42
"	20. Section of <i>Juniperus horizontalis</i> dune- - - - -	47
"	21. <i>Salix glaucophylla</i> dune - - - - -	51
"	22. <i>Betula alba papyrifera</i> dune - - - - -	53
"	23. <i>Juncus balticus littoralis</i> relic dune - - - - -	54
"	24. Disruptiv action of water freezing in a relic dune- - -	55
"	25. Man-made dune - - - - -	56
"	26. Travelling dune near Kenosha, Wisconsin - - - - -	57
"	27. Growth habit of <i>Sporobolus cryptandrus</i> in a blowout - -	59
"	28. <i>Andropogon scoparius</i> bunchgrass - - - - -	64
"	29. <i>Petalostemum purpureum</i> in the bunchgrass association- -	67
"	30. Heath north of Beach, Illinois. - - - - -	72
"	31. Growth of <i>Quercus velutina</i> near Beach - - - - -	81
"	32. Blowout in <i>Quercus velutina</i> - - - - -	86
"	33. Blowout in the heath- - - - -	87
"	34. Blowout in <i>Quercus velutina</i> going to prairie- - - - -	87

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Introduction.

During 1907 it was suggested by Dr. H. A. Gleason of the University of Illinois that I work up the plant Associations of the beach region from Waukegan, Illinois to Kenosha, Wisconsin for a thesis. Accordingly the following two summers were utilized in field work in the region and during the school term the results were written up under the immediate supervision of Dr. Gleason. To him I owe the greatest obligations for innumerable suggestions both in interpreting the data and putting it in written form. To Dr. H. S. Pepon of the Lake View High School, Chicago and to Dr. C. C. Adams of the University of Illinois I am indebted for suggestions and other helpful features. The data for plotting the climatic factors was obtained thru the courtesy of the Chicago and Milwaukee offices of the United States Weather Bureau and the data for the levels of Lake Michigan from the City Engineer's office in Chicago.

The nomenclatur used is essentially that of the seventh edition of Gray's Manual as that is the latest taxonomic work, tho on account of its broad generic interpretations, it is by no means adequate to the present state of advancement.

The spelling used is in accordance with the rules and recommendations of the Simplified Spelling Board and set forth in their publications.

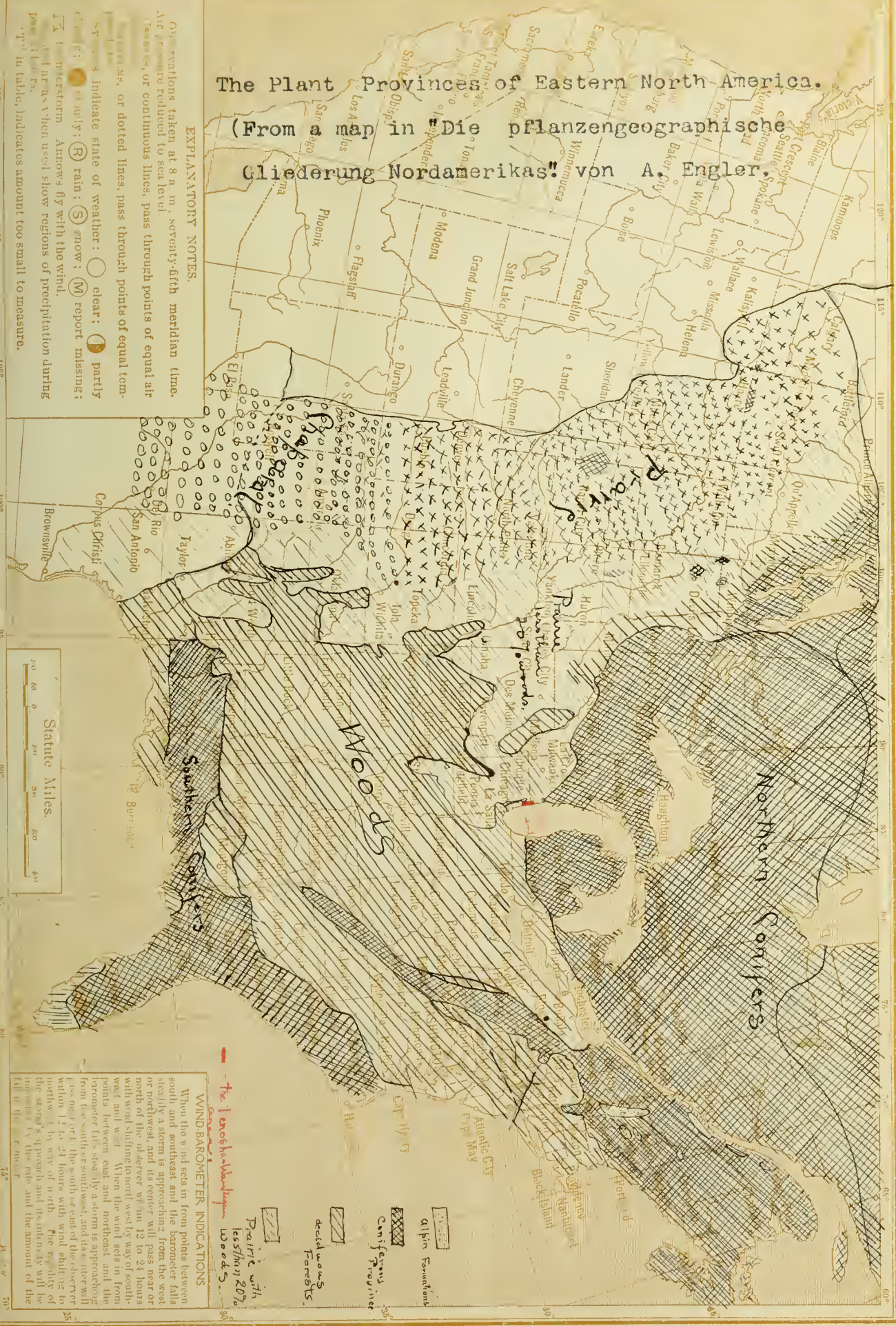
As may be seen in the map of North America following, (fig.1) the region under consideration is located near the northern boundary of the deciduous forest province and not very far from the eastern boundary of an arm of the prairie province. At the same time it is near the southern boundary of the coniferous forests and has within its area associations that are relics of that province. The purpose of the work was to obtain a clear idea of the extent

The Plant Provinces of Eastern North America.

(From a map in "Die pflanzengeographische Gliederung Nordamerikas" von A. Engler.)

EXPLANATORY NOTES.

Observations taken at 8 a.m., seventy-fifth meridian time.
Air at source reduced to sea level.
Temperature, or continuous lines, pass through points of equal temperature, or dotted lines, pass through points of equal temperature.
Symbols indicate state of weather: ○ clear; ● partly cloudy; ☉ sun; ☂ rain; ☄ snow; ☄ report missing; ☄ thunderstorm. Arrows fly with the wind.
Precipitation, or as shown, use show regions of precipitation during precipitation.
In table, indicates amount too small to measure.



and floristic composition of the associations of this region, upon which to base further work upon the successional relationships between the competing associations of the three provinces which are represented in this area.

Altho this region had been visited for collecting purposes during the four years previous to 1908, work upon a strictly ecological basis was pursued only during the seasons of 1908 and 1909. A summary of the trips taken is here presented in tabular form.

Date	Numbers collected	Persons accompanying.
Jun 8, 1908.	2448-2526	----
Jun 29.1908.	2743-2779	N.L.Partridge and J. Sanford
July 1.1908.	2780-2827	N.L.Partridge, Dr.H.S.Pepoon and Prof. L.M.Umbach.
July 10.1908.	2828-2864	Mr. Carl Durand
July 27.1908.	2865-2875	Dr.H.A.Gleason
Aug 3.1908.	2876-2907	-----
Aug 7.1908.	2908-2924	Mr. Durand
Aug 14.1908.	2925-2946	-----
Aug 21.1908.	2947-2975	-----
Aug 28.1908.	2976-2993	-----
Oct 31.1908.	2995-2997	-----
Dec 25.1908.	-----	N.L.Partridge
Jan 1.1909.	-----	R.R.Sleeper
Jun 16.1909.	3014-3040	-----
Jun 22.1909.	3041-3065	-----
July 12.1909.	3078-3126	-----
July 19#1909.	3127-3163	-----
July 28.1909.	3164-3182	-----
Aug 17.1909.	3201-3207	N.L.Partridge
Aug 24.1909.	3208-3221	-----
Aug 30.1909.	3223-3259	-----
Sept 4.1909.	3260-3278	-----
Sept 11.1909.	3279-3284	-----
Oct 17.1909.	3285-3292	-----
Nov 24.1909.	-----	-----

Three nearly complete sets of the plants of the region were collected, one of which has been deposited in the Herbarium of the University of Illinois and another is in the author's private collection.

Description of the Region.

Geografically this area is located along Lake Michigan, extending from Waukegan, Lake County, Illinois to Kenosha, Kenosha County, Wisconsin, lying between $42^{\circ} 21'$ and $42^{\circ} 35'$ North Latitude and between $87^{\circ} 48'$ and $87^{\circ} 49'$ West Longitude. The western boundary of the region as taken under consideration is the Glenwood ridge, which was the upper limit of glacial Lake Chicago of which a brief discussion will follow shortly. The region is entirely covered by the Racine (Wisconsin) and the Waukegan (Illinois-Wisconsin) quadrangles of the United States Geological Survey. The latter is by far the more detailed sheet and covers the greater part of the area. Parts of these two sheets have been used directly in making up fig. 2. The range in altitude is very slight. The highest elevation on the Beach region proper is but nine meters while virtually all of the region with the exception of a few of the ridges is less than five meters above the level of Lake Michigan. The Glenwood Ridge which forms the western boundary is about 17 meters above the Lake Michigan level.

Geologically the region consists of a sand and gravel beach superimposed upon glacial clay. In but one place, so far as the author has been able to discover, is the clay exposed. The sand is arranged in long ridges nearly parallel to the present shore line. Between the ridges are swales, only a few of which are able to drain directly into Lake Michigan. Drainage is largely accomplished by steepage of the water thru the sand and finally into the lake. In the vicinity of Waukegan, as indicated upon the map, (fig.2), are two bodies of water located at practically lake level. These drain into the lake only during periods of rather heavy rainfall and during the spring thaws.



History of the region since glacial times.

The western boundary (Glenwood ridge) of the region under consideration was formed by Lake Chicago, the body of water that occupied the southern end of the Lake Michigan basin during the retreat of the Late Wisconsin Glacier. This glacial lake had a southwestern outlet into the Illinois River. By erosion of the outlet the lake level was reduced to 16.8 meters (55 ft) above the present Lake Michigan. The phenomenon known as "stopping" caused a rather sudden transition from the Glenwood level to the Calumet level which was about 10.6 meters (35ft) above the present one. During this period the ice sheet retreated into the north until a low pass to the northeast was uncovered which caused a lowering of the lake to below the present level. A readvance of the ice sheet raised the water up to approximately the 7.6 meter level which is known as the Tolleston stage. At that time Lake Maumee which occupied the upper Erie and lower Huron basin emptied into Lake Chicago thru the Grand River, which flowed across the present state of Michigan. Withdrawal of the ice sheet uncovered an opening in the Mohawk valley thru which was drained Lake Warren, formed by the coalescing of the lakes in the Huron, Erie, Ontario and Saginaw basins. Contemporaneous with this new outlet was the abandonment of the Grand River outlet into Lake Chicago. As the ice withdrew further the lakes in the Michigan and Huron basins coalesced thru the straits of Mackinac and the dismemberment of Lake Warren followed. With the uncovering of the Superior basin the lakes of the region together with the Michigan and Huron basins formed Lake Algonquinⁿ which at first had a discharge thru Port Huron and at times of high water thru the Chicago outlet also. It seems possible, in addition, that there may have been an outlet to Lake Iroquois thru the Trent valley in Ontario. The land in the

northeast began to rise when releavd of the weight of the glacier and both Chicago and Port Huron outlets were in use until the Port Huron outlet was lowerd, which then receivd all the drainage.

The next step was the opening of a pass near North Bay, Ontario which resulted in what is termd the Nipissing Great Lakes. These were at a low stage and discharged thru the northeastern outlet. Warping of the land there, however, finally brought the water up to the Port Huron level and when the land in the northeast continued to rise the Port Huron outlet was resumd. From that time to the present such changes in level as hav occurd are due to the widening and deepening of the Port Huron channel and to the fluctuations incident to variations in rainfall. Above is a brief resumé of the main points in the history of the lakes since the time of the glaciers. More detaild accounts can be found in nearly any work dealing with the geology or fysiografy of the region of the Upper Lakes. The two following hav been consulted especially:

Goldthwait, J.W. The Abandoned Shore-Lines of Eastern Wisconsin. Wis.Geol.& Nat.Hist.Survey, Bull 17:2-9. 1907.

Goldthwait, J.W. The records of the extinct lakes. Ill. State Geological Survey, Bull 7:54-68. 1908.

The beach area itself consists merely of sandbars which were formd during the Tolleston stage at which time the water was cutting into the Calumet ridge. The sudden drop in level which ended the Tolleston stage left these sandbars emergd. Formerly this terrace extended along the whole border of the lake but with the elevation of the water during the Nipissing stages the greater part of the terrace was washt away except in the Chicago district and in the area north of Waukegan. This interpretation which signifies that the ridges are of equal age is substantiated by the observations upon the plant associations. In Jennings's work on Presque Isle,

as discust in the historical development(Jennings: A Botanical Survey of Presque Isle: 294-305, 1909) the ridges were formd at different dates and a line of plant successions could be ^atrced which affirmd the fysiografic interpretation. In the Waukegan area, however, evidence goes to show that with the exception of the fringing dune from Zion City down to Waukegan the ridges were formd at one time. The fringing dune as it now exists is undoutedly a product of historic times. Since the piers that protect the harbor at Waukegan hav been bilt, considerable sand has accumulated on the north side of them and is now beginning to show the formation of a new dunal ridge a little north of the pest house. North of Zion City but particularly between Winthrop Harbor and Kenosha the shore line is being washt away a noticeable distance wvery year. These ridges are all oblique to the present shore line but they are parallel or very nearly so to the shore line that existed at the time of their formation, namely, the Calumet ridge. The work of erosion, which bid fair to allow the lake access to the Glenwood ridge south of Kenosha as well as north of it, has been to a considerable extent checkt by the piers at Kenosha and by breakwaters behind which the lake is being artificially fild.

Climate.

There are no weather bureau stations with records of long duration in the region, and consequently the records of the stations at Milwaukee and Chicago, situated at equal distances north and south of the area, are used. It is fairly safe to assume that the records for this region in very similar sort of country may be obtaind by interpolating those given. It was impossible to obtain all the data that was desidrd. The records are given in curvs to facilitate interpretation, figs. 3,4 and 5). As climatic factors

Temperatur

1871-1906.

Milwaukee, Wisconsin

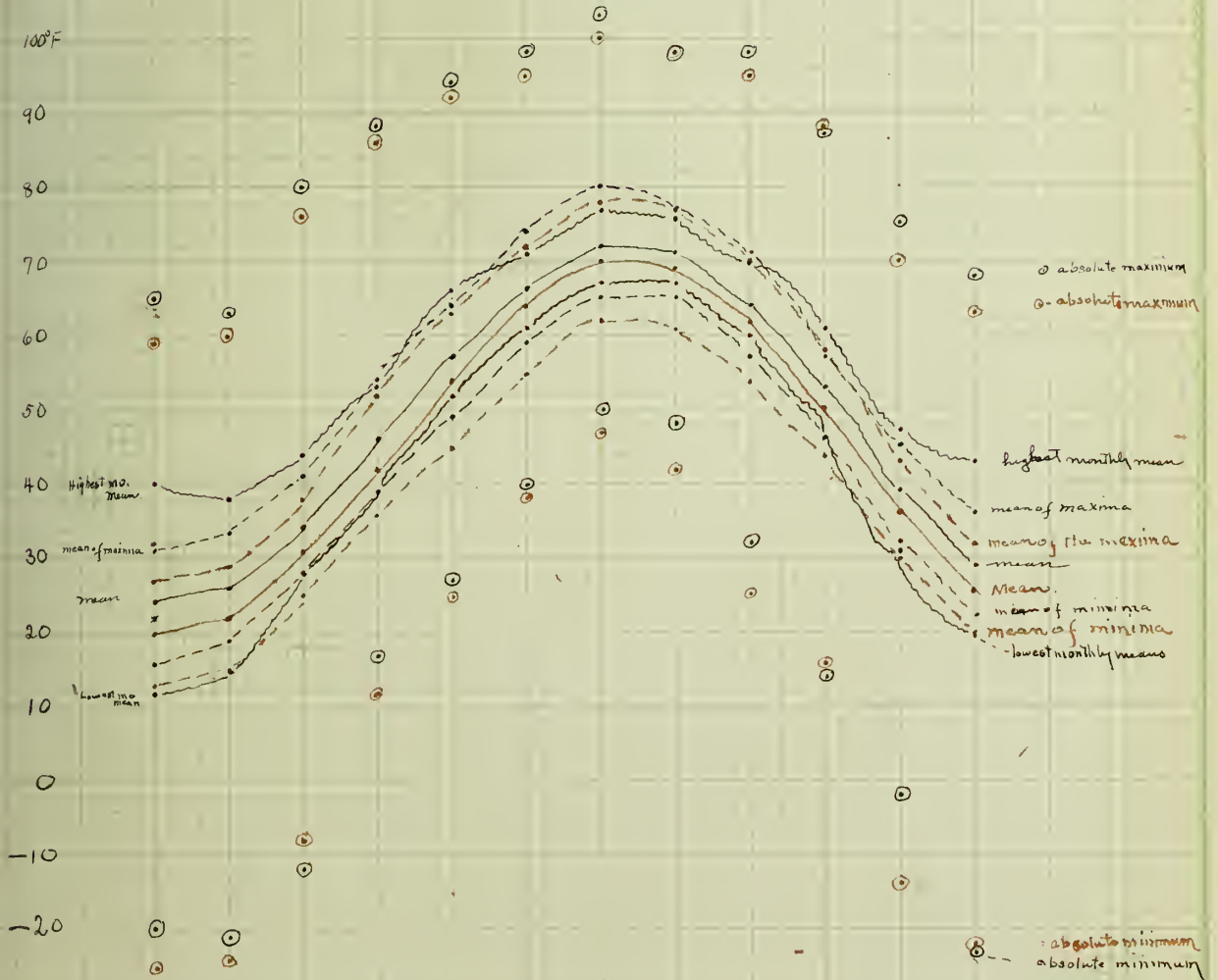
Chicago, Illinois

July 1872 - Dec 1903.

Brown

Black.

JAN Feb Mar Apr May Jun July Aug SEPT Oct Nov DEC.



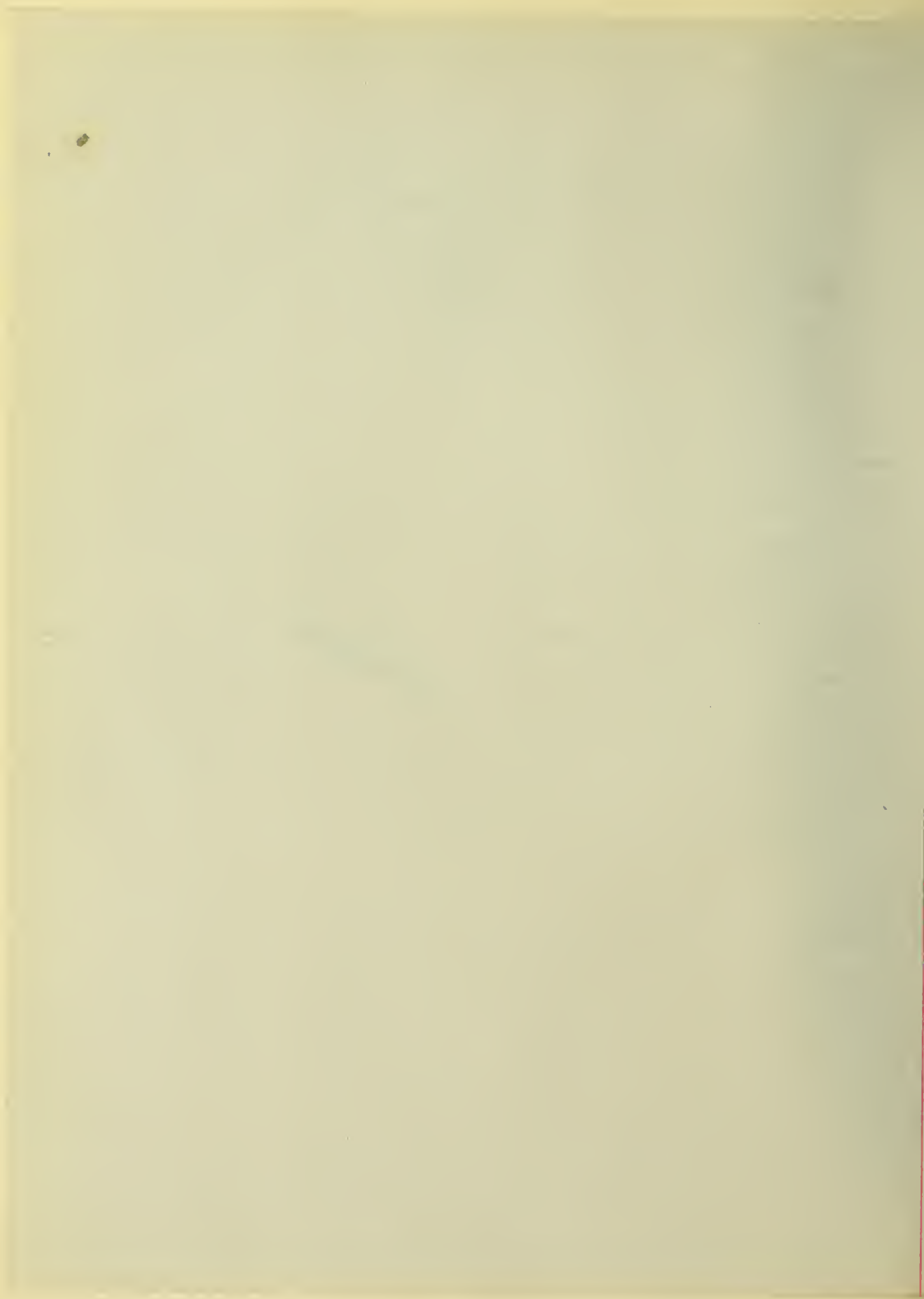


Fig 4. Precipitation Jan 1871-Dec 1906.

66

Jan Feb Mar Apr May Jun July Aug Sept Oct Nov Dec

Chicago — black.
Milwaukee — brown

9 inches

6

7

6

5

4

3

2

1

0

Total wettest yr.
Total wettest yr.
Total driest yr.
Total driest yr.

Total wettest yr. 50.36
Total driest yr. 24.4
Total wettest yr. 45.8
Total driest yr. 18.11

Mean

4 inches.

3

2

1

0

50.36

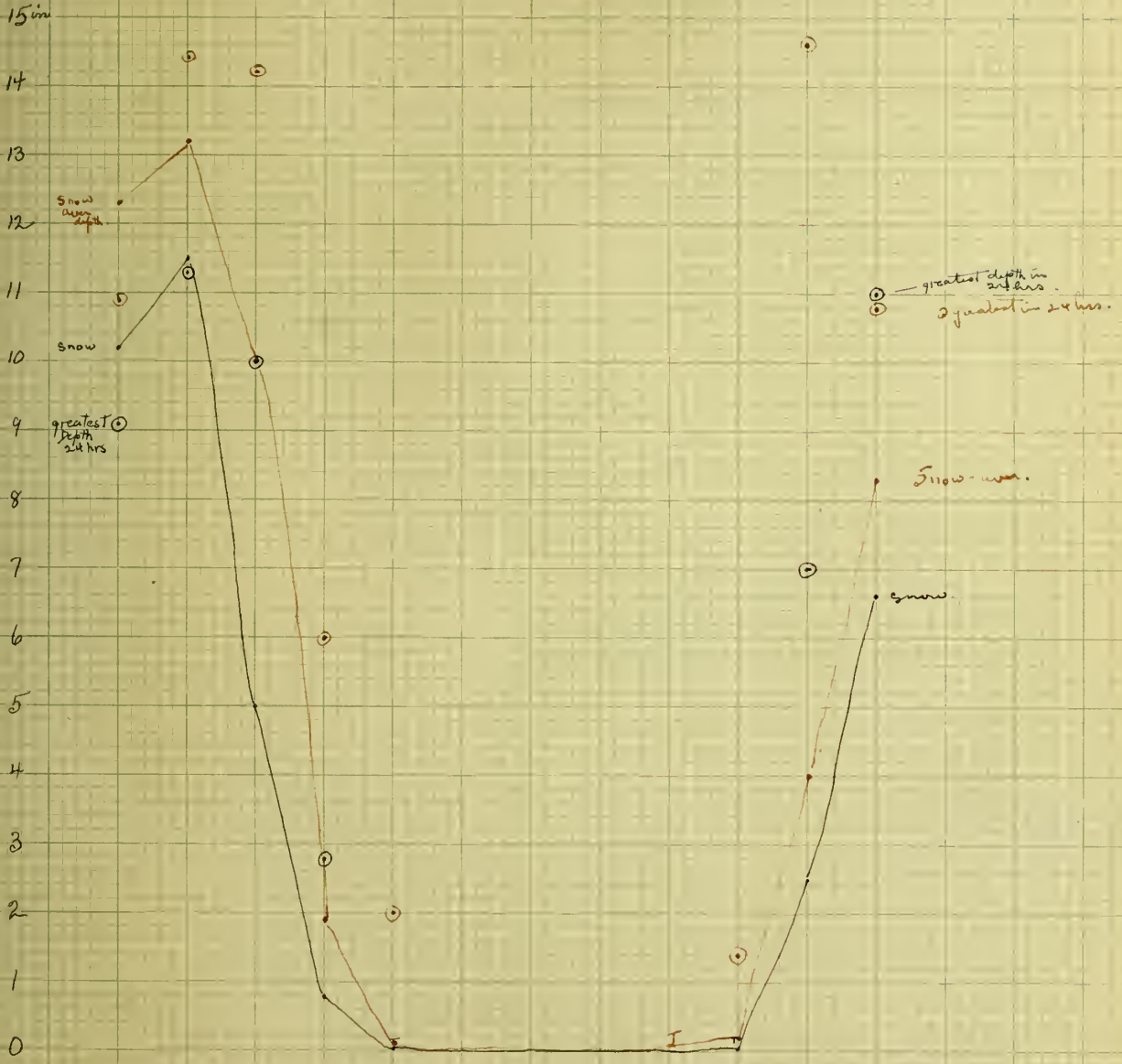
Chicago
Milwaukee

Fig. 5

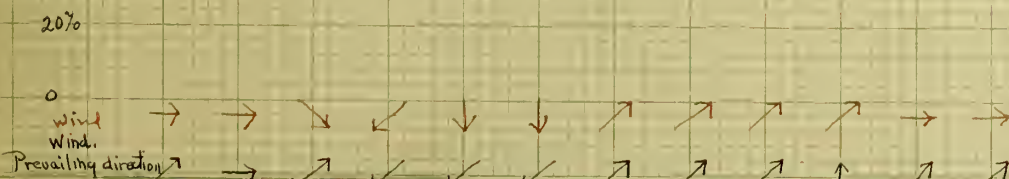
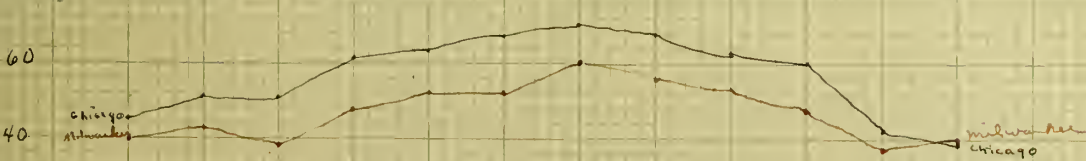
Jan Feb Mar Apr May Jun July Aug Sept Oct Nov Dec.

Snow Jan 1871 - Dec 1906.

Chicago ^{blacker}
Milwaukee - brown



80% possible sunshine. Chicago 10 yrs.



do not usually have edaphic influence they are of value only in determining the general character of the vegetation that will occupy a given area.

Edaphic Factors.

Far more important than the climatic factors in determining the floristic composition within an area are the edaphic factors. Of these the most important in itself is probably water. This region is abundantly supplied by precipitation quite uniformly distributed throughout the year. In addition it lies in the immediate proximity of the water table level of Lake Michigan, which makes it to a large degree independent of precipitation. The sandy soil is quite favorable in furnishing the plants with water which the particles of sand hold as a capillary film. The physiological supply is probably about 95% of the physical supply.

What seems to me to be the second factor in importance is the soil or the food materials. Sandy soil is notably deficient in soluble food material. The relatively rapid eremacausis, characteristic of sandy soils, caused by ready admission of atmospheric oxygen, accounts for the destruction of much of what would have been available plant food under other conditions of environment. Furthermore, soluble materials and even insoluble ones also are gradually leached out of the soil as the rain percolates through the soil rather than running off as in most soils.

With respect to light, plants of the sandy soils thrive best with a maximum and this partially explains the lack of density in the vegetation under the trees on the sand. Wind has a marked influence upon the vegetation of the dune regions, although for the most part its action is upon the environment directly and only more or less in-

directly upon the plants. Wind increases the evaporation of water from the plants, but many of those which are modified to reduce transpiration have an abundant supply of water, so at least to a certain extent such modification is inherent in the species and is not provoked by the direct effect of the environment.

Influence of Lake Michigan.

Lake Michigan exercises a leveling influence upon the region in so far as temperature is concerned. The most evident influence is of course upon the shore itself, which in places is built out and in others is torn down. This has a very marked effect upon the beach associations as will be discussed in the proper place. The fluctuations of the lake within the last sixty years are shown in figure 6. An occasional occurrence which may violently modify the vegetation but which does not occur sufficiently often or powerfully to modify the vegetation permanently are tidal waves, such as occurred April 29th, 1909. Such waves are seldom over 1.5 meters in height and are so short in their duration that the fringing dune has practically always been able to protect the land behind it. Once the regular lake level is such that the water is at the foot of the ridges and prairies, as at Kenosha, no vegetation can prevent the steady cutting which gradually eats away the ridges, prairies and marshes. Piers are built to combat this erosive action but as a rule they merely retard the action and do not stop it.

General description of the region.

This region lying between the Glenwood ridge on the west, Lake Michigan on the east, Kenosha on the north and Waukegan on the south is very shallowly crescent-shaped. Its northern and southern boundaries are marked by the extensions of the Glenwood ridge into the

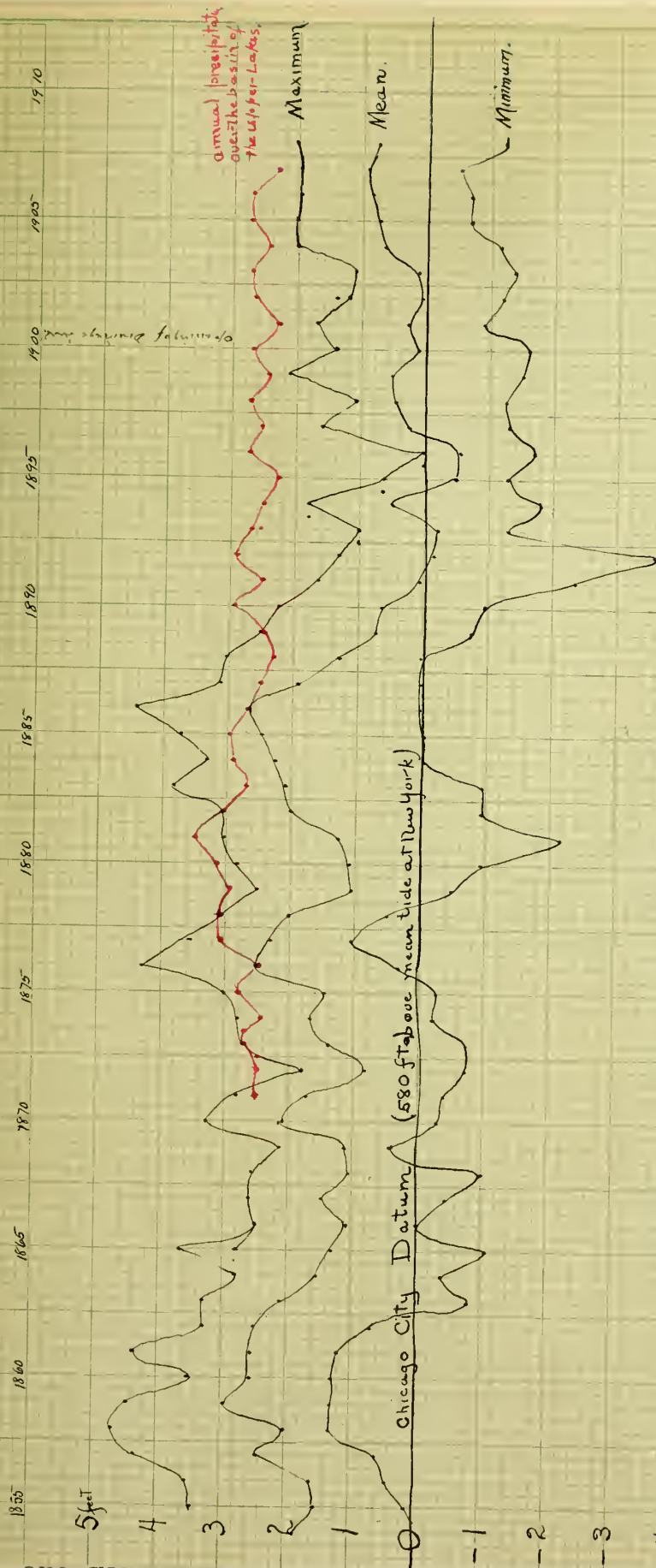


Fig. 6. Fluctuations of Lake Michigan Levels since 1854.

(Data from "Mayor's Message and 32nd Annual Report of the Department of Public Works, City of Chicago 1907.")

the south, are for the most part wider and are occupied by prairie

lake as cusps. The length of the area is about 25 kilometers with a width of from 0.4 to 1.6 kilometers. The height varies from 0.5 to 9.0 meters. The soil is sandy thruout.

As seen from the Chicago and North-Western Railway, which skirts the western edge, the different parts of the region give the following general impressions. From Waukegan to a kilometer north of the Lake County Pest House the land is characterized by marshy swales separated from one another by very low sandy ridges. In no place are these ridges 2.0 meters above the level of Lake Michigan. The vegetation is essentially prairie-like and is very monotonous in appearance, except during July when the lilies are in bloom and during September when it is covered with blazing stars. The swales are uniformly occupied with swamp grasses, etc., all of which appear much alike from the train. There are at very long intervals scraggy trees which hardly break the monotony.

North of this area is another which, tho of the same physiographic character, gives an entirely different impression because of the groves of pine that occupy the ridges. In consequence this portion is termed the area of the pines. It is bounded on the west and north by arms of the Dead Lake. Formerly the extent of this area was much greater both north, south and west but upon those sides it is being reduced by cutting, burning and by natural successions while the fringing dune and the lake form its eastern boundary.

From the Dead Lake north to Kenosha is the area of greatest extent. It is a wooded area but in this case the trees are oak instead of pine. There are many blowouts, those towards the north being larger and slightly more numerous than those in the southern part. The interridgial depressions, which are not so low as those towards the south, are for the most part wider and are occupied by prairie

rather than by marsh plants. At the Illinois-Wisconsin state line the innermost oak ridge has been cut away, leaving an area of level 1. kilometer in width sandy ground, from the lake to the bluff in which the highest elevation is scarcely 0.5 meters.

Nearer Kenosha occurs the last oak ridge which is quite wide and has several large blowouts one of which is shown in fig. 7.



Fig. 7. Large blowout where *Quercus velutina* has been cut. Clumps of *Salix glaucophylla* in the bottom with *Elymus canadensis*, *Euphorbia polygonifolia*, *Sporobolus cryptandrus*, *Oenothera rhombipetala*. *Monarda punctata* with *Cyperus schweinitzii* around the edges. Nov 23 1909.

The end of this ridge is about a kilometer south of Kenosha. It is shown in figur 8. It is being rather rapidly cut into by Lake Michigan. A little north of the end of this ridge and protected by it on the south and west occurs the only travelling dune of this area and even it is a very small one in comparison with those at the head of Lake Michigan. The part between the oak ridge and the railway track

is a sodded sandy plain.



Fig. 8. An oak ridge near Kenosha, Wisconsin which is being washed away by Lake Michigan. Nov 23.1909.

Just south of Kenosha measures have been taken to prevent the rapid cutting away of the shore that had been going on. Consequently the natural conditions have been destroyed. A little north of Kenosha the Glenwood ridge has been cut into by the lake and there the region under consideration terminates.

Associations: General discussion.

In the naming of the ecological units there is still a great deal of confusion. The author adopts the term "association" to designate the ecological unit. By an association he means a group of living forms whose epharmony enables them to liv together as a uniform or homogeneous area of definit biotic composition.

As he is working on the plant side mainly the associations will usually be spoken of as plant associations in this article. It must be borne in mind, however, that animals, especially the smaller ones, are an essential part of the association. Their ecogical relationships and corelations hav in general not been sufficiently workt out to accord them their proper consideration.

The term association rather than formation has been used, because of both priority and of natural fitness. The term association was first used by Humboldt (1807:17) in "Essai sur la Géographie des Plantes". For example: "Les bruyères, cette association^{*} de l'*Erica vulgaris*, de l'*Erica tetralix*, des lichen *icmadophila* et *haematomma* se répandent depuis l'extrémité la plus septentrionale du Jutland, par le Holstein et le Lunebourg jusqu'au 52 degré de latitude". The association is definitely named by its floristic elements.

The term formation on the other hand has a different meaning. Dr. A. Grisebach proposed the term to cover the featurrs of vegetation that are apparent to every layman, viz., a meadow, a wood, etc.. His definition of formation is found in "Über den Einfluss des Klimas auf die Begrenzung der Natürlichen Floren" publisht in 1838. It is as follows: "Ich möchte eine Gruppe von Pflanzen, die einen abgeschlos=

*underlining mine.

senen physiognomischen Charakter trägt, wie eine Wiese, ein Wald, u.s.w., eine pflanzen=geographische Formation* nennen. Sie wird bald durch eine einzige gesellige Art, bald durch einen Complex von vorherrschenden Arten derselben Familie charakterisirt, bald zeigt sie ein Aggregat von Arten, die, mannigfaltig in ihrer Organisation, doch eine gemeinsame Eigentümlichkeit haben, wie die Alpentriften fast nur aus perennirenden Kräutern bestehen".

To use the term formation for the name of the ecological unit is clearly a misinterpretation of Grisebach's statement. Yet Ascherson (1883:728), Kerner (1891:830), C.Schröter und Kirchner (1902), Kearney (1900), Ganong (in 1902 but correctly in his later articles), Clements (1902, etc.), Jennings (1908 & 1909) all follow this course. Cowles (1899:111) suggests that formations and associations are not synonymous but ignores the difficulty by using the term "plant-society". This is, as he says, a literal translation of "Plantesamfund" the Danish word which Warming used. A year later Harshberger (1900:636) uses the term formation in the same sense as Grisebach did, but the units which he included under it were designated as "zones" and "societies".

In the second German edition of "Lehrbuch der Ökologischen Pflanzengeographie" (1902:8-10), Warming states that Grisebach's term formation was composed of smaller groups which Drude (1889:17) called "Bestände", a term introduced by Schouw (1823). The same year Jacard (1902:350) differentiated between formation and association and, from the analytical standpoint, gave the following definitions, using the term Bestand (= association): "Die Bezeichnung Formation

*underlining mine.

reservire ich für eine Pflanzengesellschaft, welcher einzelne vorherrschende "ökologische Factoren ein bestimmtes physiognomisches Gepräge verleihen. Die Formation ist einheitlich auf grösse Strecken und bildet einen Factor im Landschaftsbild (Wiese, Wald, Moor, etc.)" "Bestand (association) bezeichnet eine floristisch bestimmte Pflanzengesellschaft innerhalb einer Formation, bedingt durch secundäre Factoren. Dadurch können die Verschiedheiten innerhalb ein und derselben Formation charakterisirt werden, nach einer oder mehreren dominirenden Arten und Begleitpflanzen."

In the English translation Warming (1909) definitely uses the word association, which he explicitly states is not synonymous with Grisebach's "formation" but is included under it.

Approaching the question from an analytical standpoint, Warming (1909:140) defines a formation as "an expression of certain defined conditions of life" which "is not concerned with floristic differences", and an association as "a community of definite floristic composition within a formation", to which he adds; "it is, so to speak, a floristic species of a formation which is an ecological genus." The ecological unit (association) is equivalent to the taxonomic unit (species). Just as species are grouped to form a genus and genera are grouped to form a family, so are associations grouped to form a formation and formations are grouped to form a province. If necessary an association may be divided into consocieties, in like manner as species are divided into subspecies.

Of the apparent properties that ecological associations and taxonomic species have in common, Harper (1906:33-34) gives the following very pithy statement: "There are many analogies ^{between} habitat-groups and taxonomic groups, such as species, though the latter are mutually exclusive categories and the former often are not. For in-

stance, both are able to be discovered, described, named, and associated with certain type-localities. Records of both may be preserved by descriptions, photographs, measurements, and other means. Both have their diagnostic characters, with more or less variation and intergradation. Both have passed thru processes of evolution, are self-perpetuating, and are liable to disappear thru geological or climatic changes of the works of man. New ones may also originate, suddenly or gradually. Both have more or less definite geographical distributions and regions of best development. Both are capable of being subdivided, combined, or relegated to synonymy, with the increase of our knowledge concerning them. Habitat-groups, like species can also be aggregated into larger categories, analogous to genera and families."

Just as genera and species present difficulties of delimitation so do formations and associations. The difficulties of ecological classification show many points of similarity and require fully as much study and experience for solution as do those of taxonomic classification. The criteria that have been used in delimiting and classifying associations have been almost as various as writers upon the subject.

Jaccard (1902:350) says, "Im allgemeinen ist der Bestand bestimmt durch die dominirende Art oder Arten". He was the first to set up a mathematical criterion for distinguishing associations. The association- or community-coefficient (Gemeinschaftscoefficient) is obtained by dividing the number of common species, in the two areas under consideration, by the total number of species in them. For example, area A has 100 species, area B has 120 species, 60 of which are common to both areas. Then
$$\frac{60}{100 + 120 - 60} = 37.5 \%$$

the community coefficient. For areas which are in the same association and in the same locality this coefficient ought to be fairly high. That even this method has its limitations Jaccard recognized when he said, "Sie entsprechen zwar gewissen Differenzen in den ökologischen Bedingungen der verglichenen Territorien, aber es besteht zwischen dem absoluten Werth dieser Differenzen und dem der Gemeinschaftscoefficienten keine mathematische Proportionalität". This same method was independently arrived at by Professor S.A. Forbes in his statistical study of Illinois fishes (Art 8, Bull 7, Ill. State Lab. of Nat. Hist. 1907).

Besides the floristic composition told by mathematical methods, associations are usually appreciated by any or all of the following characteristics: 1) the presence of one or more dominating species, 2) the presence of tension lines at their boundaries, 3) the presence of evidences of dynamic succession, usually shown at or near the tension line, 4) the presence of a uniform environment, 5) the inability of species of different associations to mix, and 6) the presence of the similar vegetative forms and environmental adaptations.

The Beach Associations.

The Chlamydomonas Association.

The classification of lake beach regions, heretofore, has been founded upon a physiographic basis, in which the features distinguished were Lower, Middle and Upper Beaches. The Lower Beach has been defined by Cowles (1899:113) as "that zone which is situated between the water level and the line reached by the waves of common summer storms." An alternate definition is given on page 114: "It might almost be defined as that portion of the beach which is devoid of

vegetation". The lower beach, fysiografically speaking, exists in two modification; one consisting of a very gradual slope which may be concave and the other of a relatively steep slope. Shown in profile they appear thus.



Fig.9. Profiles of the two types of lower beaches.

Beaches of type A. are but very little elevated above the average level of Lake Michigan and the sand is damp, either to the very surface or at least to within one or two millemeters of it. Just at the edge of the lake is a little ridge which permits water to be retained beyond it. This water forms what is termed a beach pool. Being so near to the level of the lake drainage back into the lake is very slow. In rainy seasons or at times of frequent north to southeast winds the beach pools may remain for a long time. During the ordinary growing season the sand is never sufficiently dry to be blown about in the wind. In beaches of type B. the slope is much greater and the water from each wave drains away very rapidly. As a result two to three centimeters of dry sand form the surface. This sand is, of course, easily blown about in the wind.

In neither of these two types of lower beaches is there vegetation of a permanent natur. In beaches of type A. the one-celd motil alga, Chlamydomonas, together with Oscillatoria may occur in such numbers as to cause the wet sand to appear green. This constitutes the Chlamydomonas association. These algae occur also in the waters of the lake but their optimum habitat is the beach pools which occur near the outlets of sewers or near the mouths of

creeks bearing sewage such as is shown in fig. 10. The sand around



Fig. 10. Beach pool showing Sanderlings feeding.
August 17 1909.

the pool is mushy and rather greenish in color. The ridgelet between the beach pool and the lake is very low (10cm at most) and very narrow. Every north to southeast wind will cause the waves to run over the ridge and flood the pool with sewage-laden water from the nearby sewer. This constant flooding together with the rather frequent rains resulted in a permanent pool during the season of 1909. Small snails appeared and upon them as well as upon other living forms the sanderlings shown in the figure are feeding.

Aside from the algae, vegetation upon the lower beach is purely accidental. One such case is that of a large willow log which was broken in three pieces and washed up to the edge of the lower beach by the tidal wave of April 29th, 1909. The original source of this log is not known, for nowhere in the beach region are there willows of such size. The logs lie just within the reach of every ordinary wave. Succeeding storms have partially covered the logs with sand which

is constantly kept moist by the waves. From the logs themselves adventurous shoots have grown to the height of six decimeters. Whether these logs will withstand the winter storms and together with some wreckage nearby originate another ridge remains to be seen.

Another case of accidental vegetation on the lower beach is very temporary in duration and extent. It occurs south of Kenosha where Lake Michigan is cutting into the prairie. Some prairie plants, notably *Lythrum alatum*, are carried bodily from the prairie and are occasionally left stranded with their root systems in the damp sand of the lower beach. They remain living until washed away altogether by a succeeding storm.

The part of the lower beach which is devoid of plants and hence cannot have an associational name comes next into consideration. The area is bare because plants cannot obtain a footing there - and not because they will not grow there. The reasons which are given briefly by Cowles (1899:114) and more fully by Jennings (1909:310) are as follows: the alternate washing by storm waves and the severe drying out under the sun combined with the washing about of the sand when submerged and the blowing about when dry prevent the ecesis of any plants whose seeds actually do germinate. After a rainy spell of two or three days duration such as Aug 13-15, 1909 it is not at all a difficult task to find, scattered over the slightly damp sand, seeds which have begun to germinate. With the reappearance of the sun and the drying of the surface sand, these partially germinated seeds dry up and are blown about in the wind. That living forms, however, can maintain themselves on this area is clearly shown by the industry of the turnstone (*Arenaria interpres*) which during their brief sojourn in this region in their spring and fall migrations are continually

occupied in ferreting out the small insects and other animals which are found under the pebbles. The junction of this area with the portion of the beach continually washt by the waves is the location of the willow log and the wreckage mentiond above. One piece of wreckage is a little over a meter in length and projects somewhat over a decimeter into the air. The ordinary waves just fall short of its lakeward side. On the landward side stretching southwestward is a miniatur dune of sand in which are growing the following plants:

Juniperus horizontalis - a single healthy shoot, 3cm in length
growing next to the wreckage,
Prunus pumila - a sprawling shrub,
Poa compressa - a few plants,
Potentilla anserina - one plant with five radiating runners,
Equisetum arvense - a few specimans,
A composit which was so depauperate as to be unrecognizable, and
A convolvulaceous-looking plant, together with exposed roots of
Calamovilfa longifolia.

A wagon track thru the dune explains the planting of the Potentilla, the composit, the Equisetum and the convolvulaceous plant for they were growing in bottom of it. The nearest source for the Juniperus was nearly a hundred meters away, from which the seed may hav been carried by the gulls which are abundant on the beach and occasionally are to be seen in the heath.

Close to the lee (SW) side of another piece of embedded wreckage in this same vicinity was a straggling plant of Xanthium commune.

Taking all these facts into consideration it seems evident that a new ridge is being thrown up. The pieces of wreckage were probably lodged there during the violent storm and tidal wave of May 12, 1905. The juniper came in the backwash of that storm or by other agency in 1906, as it appears to be three or four years of age. The storm and wave of April 29, 1909. did not dislodge the wreckage nor the juniper. It added material that can assist in the formation of the ridge. Progress towards that end is, however, very slow.

The Chlamydomonas association is entirely identical with the Chlamydomonas formation of Jennings at Cedar Point (1908:313) and at Presque Isle (1909:310). Occasional presence of the alga was reported by Cowles near Porter, Indiana (1899:114). This association together with the plantless area compose what MacMillan termed the front strand.

Cakile-Xanthium Association.

Location

From the upper limits of the open sand, therfor out of reach of the ordinary storm waves, an area of nearly open sand stretches inland. The landward boundary is usually the fringing dune.

Fysical environment.

A resumé of the fysiografic characteristics of this association is not out of place. A full discussion is found in Cowles (1899: 115-117) and Jennings (1909:311). The middle beach, as Cowles designated it, lies "between the upper limits of the summer and winter waves". It is dry in summer and differs from the lower beach only in that it is not subject to the mechanical violence of the waves during the growing season. The soil is for the most part sand whose grains vary between 0.2 and 1.0mm in diameter. It is exposed to the full force of wind and sun and consequently is very dry nearly all of the time. During the daytime the sand becomes very hot (60°C) but it cools off rapidly during the evening. Altho the upper few centimeters are so very dry, the sand beneath is always moist and may be even wet.

Ecological Characteristics.

The plants that persist in this association possess certain general characteristics: 1) they are annuals, because perennials are

uprooted during the winter storms, 2) their disseminⁱⁿula are comparatively heavy so that, tho they are blown about, they are not blown away, 3) their seeds hav sufficient vitality for sending their tap roots thru 4-10 cm of dry sand to the moist sand below, and 4) their aerial parts are low, radiately branching or bushy, narrow-leaved and frequently succulent. In other words the plants of this association are subjected to the severest kind of xerofytism. Such a habitat, hydrofytic beneath the surface of the ground and xerofytic above ground is termed dissofytic by Clements.

Development.

In the Beach area the middle beach, to use Cowles's term, exists in two modifications. Towards the southern end the middle beach is highest at its boundary with the lower beach, from which it slopes very gradually down to the fringing dune, a slope of but a few centimeters at most. Towards the north the narrow middle beach slopes upwards and abruptly gives way to the much higher (2-4 meter) fringing dune. Here the middle beach is subject to continual removal of its sand by the prevailing westerly winds. As the winds are in the westerly half of the compass more than half of the time, the formation of extensive or high dunes is impossible on account of the lack of sand. The replenishment of the sand of the middle beach takes place during the easterly storms of which there are but a few each year. Such storms, as a rule, are accompanied by precipitation which further retards their power of bringing up sand from the lake. The amount of sand that such a storm may pile up may be judged from the storm of July 30-31, 1908, in which the wind was east for a day and a half. A ridge some 20 meters wide and 0.4 meters high was piled up in front of the mouth of the Dead River, completely closing the channel, 6 meters wide and 0.5 meters deep in the center, which

that river had had the day previous. This does not begin to compare with the amounts blown up on the southern and eastern shores of Lake Michigan. Some sand is blown up during the winter unless the shore is icebound. At that season that is a noticeable transfer of sand from the northern parts, where it is held by the season's vegetation, towards the southern parts, where north of the Waukegan piers it is bilding the shore out into the lake.

The southern part is more wind swept because protected on the landward side by only a very low (at most 0.2 meter) fringing dune. It is characterized by extreme openness of vegetation. The plants th that occur, always at very widely separated intervals, are Euphorbia polygonifolia, Xanthium commune and Cakile edentula, in abundance as named. Each of these plants has to contend with a continual exposur of its root system by the removal of the sand. Euphorbia polygoni-
folia usually avoids this by living in depressions. If growing on the level, however, it forms a dense mat which holds the sand within its compass, bilding up a miniatur dune about two centimeters in hight and sometimes twenty centimeters in diameter. Such a dunelet is shown in fig. 11. If the blowing is too vigorous the plants

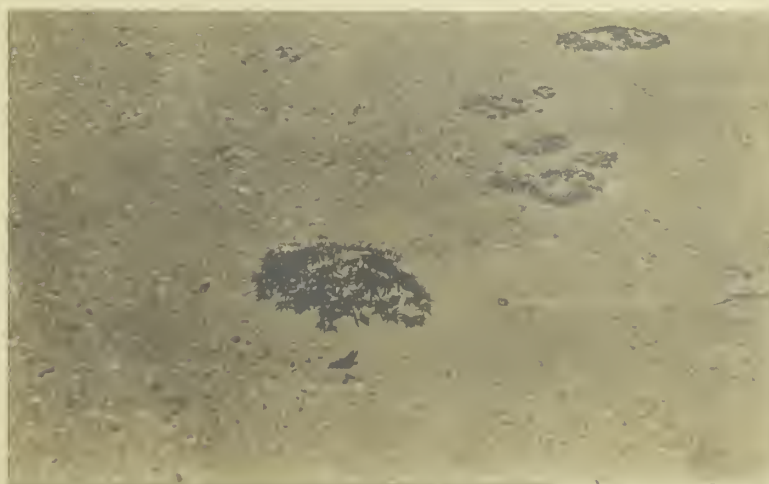


Fig. 11. Little dune formd by Euphorbia polygonifolia.
August 30, 1909.

will succumb and it is not unusual to find dead, curled-up plants of this species rolling about in the wind. There is apparently no adaptation in Cakile for the protection of its root system, but Xanthium is adapted by growing procumbent with only the apical 4-7 cm projecting into the air. The spread of leaves around the stem aids in the formation of a small, temporary dune which protects the root system from exposure. Even then plants have been found in which there was a distance of 6-10 cm from the exposed bur, from which the plant had germinated, to the point at which the root was covered with sand. This indicates that considerable sand had been removed.

Pieces of driftwood on the beach often are the starting points for small temporary dunes. Occasionally a plant of Xanthium commune will fix such a dune for a season. In the vicinity of Beach where the middle beach is very narrow and protected by a three to four meter fringing dune, the characteristic plant is Euphorbia polygonifolia. This plant is most abundant where there are pebbles to afford it protection from the wind. Cakile edentula occurs only at rare intervals, while Xanthium is virtually absent.

List of the Species of the Cakile-Xanthium Association.

Cakile edentula
Euphorbia polygonifolia
Xanthium commune

On the normal middle beach only the three species mentioned above are present. North of Winthrop Harbor, however, where the ridges and swales are being washed away by the waves, several other species are to be found on the middle beach. Their presence is both accidental and temporary. The more frequent of such plants are, Verbena hastata, Verbascum thapsus, Cenchrus carolinianus,

Fragaria virginiana, Trifolium repens, Polygonum persicaria, Potentilla anserina, Polygonum acre, Panicum capillare, Acnida tuberculata subnuda, Polygonum lapathifolium, Equisetum arvense, and Salix longifolia. In other places were the following additional species: Poa pratensis, Juncus tenuis, Cirsium arvense making little dunes, Lythrum alatum, Radicula palustris and Trifolium pratense. Altho these plants occur within the limits of the Cakile-Xanthium association, they do not properly belong to it for the following reasons. Surrounding their roots is always more or less prairie humus. Sometimes the humus is only about the individual plants. In some places there is a strip of prairie, which, when undermined by the waves, has slid down on the middle beach, carrying with it whatever plants were growing in it. Later these strips were buried with a few centimeters of drifted sand. The plants usually persist thru the one season but do not grow the next year. The burying process may keep up during the season. In general this is liable to kill prairie plants within the summer but in a few cases the following plants will keep pace with the incoming sand, namely, Panicum capillare, Acnida tuberculata subnuda, Trifolium repens and Salix longifolia.

Since these species which constitut the derived element of the association can under no circumstances commence to grow on the middle beach and since their presence there is to be accounted for solely fysical displacement of the soil upon which they were growing, and since their presence has absolutely no successional value, one cannot say that they are a real part of the association.

Triglochin palustris Association.

In describing the middle beach above, it was mentioned that in the southern part of the area its slope from the lower beach was downward towards the lake level. Just a little north of the docks at Waukegan the beach ^{has reached} the level of sand which is permanently moist clear to the surface. There is, however, no standing water and therefore no beach-pool is formed. This is the situation to which Triglochin palustris gives such a definite floristic character that it must be termed an association, even though it is isolated and small in area.

The plants of Triglochin palustris, which comprise about 70 % of the area, grow close together in small tufts. The tufts themselves are separated by intervals of two or three to ten centimeters. Toward the landward side, where the tufts of the facies are further apart, the secondary species of this association occur. They are all pioneers of succeeding associations. The most important of them is Juncus balticus littoralis, which grows on slightly higher ground than does the Triglochin. It is indicative of one of the associations that is to succeed. The secondary species, which are all invaders, are given in the species-list.

List of the Species of the Triglochin palustris Association.

- f Triglochin palustris
- i Juncus balticus littoralis
- i Potentilla anserina (sparingly)
- i Juncus torreyi (few undersized plants)
- s Juncus alpinus insignis (few undersized plants)
- i Scirpus americanus (rare)
- i Populus deltoides (a few seedlings under 12cm in height)
- i Cyperus rivularis (two specimens)

f = facies, i = invader, s = secondary species.

Juncus balticus littoralis Association.

One of the first indications of the first type of upper beach, as Cowles (1899:167 et seq.) terms that part of the beach which is entirely without wave action thruout the year, is the presence of the rush, Juncus balticus littoralis. It grows from strait rhizoms which may be over three meters in length. The lines of plants cross and recross each other in every direction. Figur 12. shows the habit of growth. Expansion on the landward side is ecologically impossible



Fig. 12. Habit of Growth of Juncus balticus littoralis, a clump of Andropogon scoparius and plants of Potentilla anserina showing also. Aug 17 1909.

because of the closed association behind it. Progress out into the middle beach is only limited by the action of the waves in winter and the winds which keep uncovering the outermost rootstalks. As the lines grow outward the shifting sand is retained around the bases of the plants. It may even form embryonic dunes to the hight of a few centimeters. This work, however, is nearly always destroyd,

when the westerly winter winds, with nothing to impede them, carry the sand back into the lake. The Juncus itself does not seem to be able to fix the dunes, but it is a pioneer that enables dunefixing plants to gain a foothold on the low and level beach such as that which, in the southern part of this area, extends from Beach to Waukegan. There is no Juncus where the slope of the shore is 15° or more. The lakeward side of this association is composed of just the one species, the facies. In the middle and landward sides other plants appear. The most abundant of these is Potentilla anserina of which more will be said in connection with the following association. Small straggling plants of Salix syrticola occur at intervals but as a component part of this association they are not well developed. Occasionally a dwarfed, small-leaved plant of cottonwood, Populus deltoides, may be seen. Because of the deficiency of nutriment in the soil the cottonwoods grow very slowly - sometimes not more than a couple of centimeters in a season. Scirpus americanus occurs here more frequently than in the Triglochin palustris association but still is not abundant. It has a remarkable tendency to grow in a spiral form when it grows in the sand. The Juncus balticus littoralis itself possesses this tendency but to a less marked degree. The presence of the Scirpus is conclusive proof that wet sand is close to the surface.

List of the Species of the Juncus balticus littoralis

Juncus balticus littoralis
Potentilla anserina
Salix syrticola
Populus deltoides
Scirpus americanus
Triglochin palustris
Cakile edentula
Cycloloma atriplicifolium
Elymus canadensis.

Association.

In addition to the part that Juncus plays in bilding up the beach, it has an important rôle. in retarding the storm waves in their attack on the shore-line between Kenosha and Winthrop Harbor. Its efforts are only partially successful as fig. 13 illustrates.

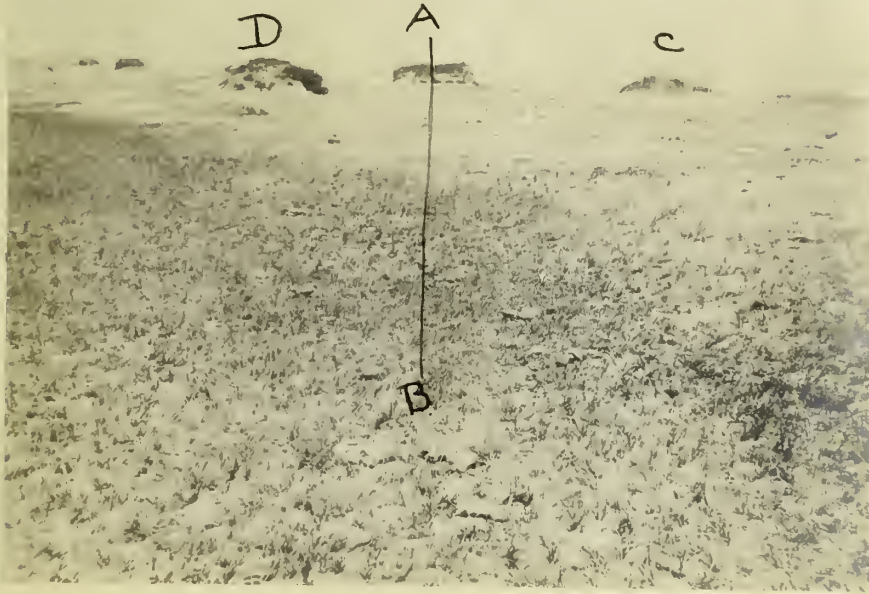


Fig. 13. Relic dunes along the shore of Lake Michigan near Kenosha, Wisconsin. D is a relic dune formed by *Juniperus nana*, the others are formed by *Juncus balticus littoralis*. August 30 1909.

The relic dune (A) in the center of the figure and the two at the left mark the limits of the grassy sand-plain in 1905. This plain is usually separated from the lake by a very dense growth of Juncus balticus littoralis. The width of this *Juncus* association is 1-3 m., and it is separated from the grassy plain by a narrow tension zone of Potentilla anserina. The interwoven mass of rhizoms of the *Juncus* protects the sand from sliding. As a result there is normally a perpendicular bluff of 1.0 - 1.4 meters high at the lake.

Repeated buffetings of the lake wear thru the *Juncus* in spots.

This affords an opening to the grassy plain behind with which violent waves make short work. The limit of wave action is due to the loss of power to move sand after the waves have proceeded over a stretch of beach. The retreating waves carry back with them sand from the rear of the *Juncus*. After about four years of such action the old beach line has the aspect shown in fig. 13 above. In the center of the figure is a relic dune. Its height above the water is the same as that of the grassy plain in the foreground. This is illustrated with the following profile (fig. 14) made along the line "AB" in fig. 13.

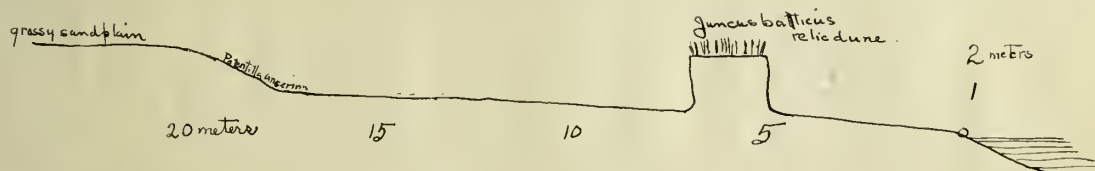


Fig. 14. Profile of beach near Kenosha, Wisconsin.
Made along line "AB" of fig. 13.

The sides of these relic dunes are coated with a dense mat of exposed rhizoms of *Juncus*. At "C" in fig. 13 is a *Juncus* dune in one of the stages of obliteration.

The flora of these interesting relics is very uniform. *Juncus balticus littoralis* is the characteristic species and occupies 95-99 per cent of the area of the caps. The following are infrequent in their occurrence and irregular in their distribution: *Oenothera rhombipetala*, *Salsola* ^{*trifida*} *tragus*, *Cenchrus carolinianus* and *Potentilla anserina*.

Proceeding southward from the portion shown in fig. 13 the shoreline begins to curve somewhat to the west and is not subjected to so much wave action. The rifts in the *Juncus* association become less frequent and of less and less importance as the shore dips away from

the direct attack of the waves. The sand is piled in at the base of the *Juncus* rhizoms so that the bluff is cycloidal in configuration. The association still contains over 90% of *Juncus balticus littoralis* but secondary species are a little commoner and more varied. The list is as follows:-

Sporobolus cryptandrus
Potentilla anserina
Cenchrus carolinianus
Cornus stolonifera
Ptelea trifoliata
Cirsium arvense
Oenothera rhombipetala and
Populus candicans.

Besides characterizing an association itself *Juncus balticus littoralis* grows in a majority for the other associations of the beach region. It will be given consideration accordingly under them. Notwithstanding its apparent disregard for habitat it rarely shows any modifications in form in the habitats in which it is evidently a relic.

Potentilla anserina Association.

From the *Juncus balticus littoralis* association the sand slopes up gradually to the *Salix syrticola* or fringing dune association. This slope is characterized by a rather dense growth of low plants of which *Potentilla anserina* constitutes from 70 to 90 %. It may be termed a tension line association and separates very distinctly the fringing dune from the *Juncus* association. *Potentilla anserina* grows in each of the three but it shows its maximum development in the *Potentilla* association. In the bordering associations the size of the individuals varies to a minimum and their number to zero. This may be grafically shown by means of a curv (fig. 15)

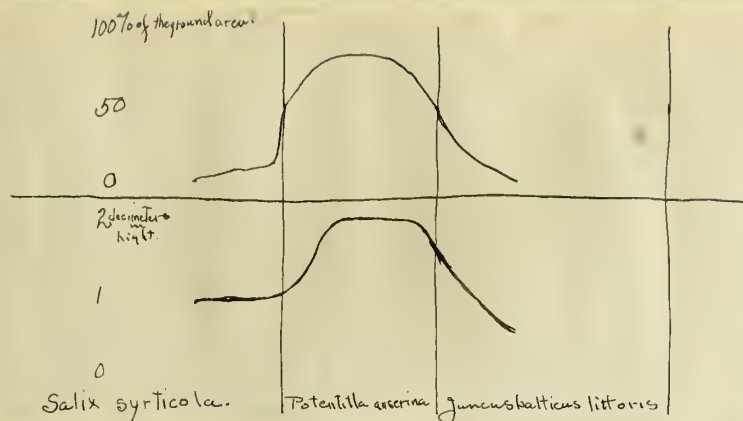


Fig. 15. showing the relative height and abundance of the plants of *Potentilla anserina* on the beach near Waukegan, Ill.

Potentilla anserina spreads very rapidly by means of runners which radiate from the parent plants. At quite regular intervals of from one to two decimeters each runner sends out roots and leaves. The new growth decreases in size with increasing distance from the center. Any accident received by the runners causes the separation of independent plants, from which new runners may extend. *Potentilla* cannot contend with the wind. It is rather easily killed either by sand being blown away from its roots or by being buried in the drifting sand. In the spring, before there is a carpet of vegetation over the ground, the young plants are to some extent protected from the wind by the bushes of Salix syrticola and the dead stems of Juncus balticus littoralis. Once a carpet is formed there is little danger of damage from the wind.

If protected from wind and still connected with the parent plant, runners may proceed thru rifts in the Juncus out upon the middle beach, where they may develop roots and leaves in the usual way but of smaller dimensions. During the season of 1908, there was an unusually small number of heavy winds and many long runners developed in this way. A number of these runners were severed resulting in the gradual starvation of the young plants, thus isolated upon the middle beach. This was probably due to the deficiency of

food material there, a fact which has often been commented upon. The season of 1909 with its heavy surf and strong wind storms prevented any such development of runners.

The secondary species of this association are not many in either number of species or of individuals. Without exception they are obviously under the usual size. This also is due to the lack of nourishment in the sand. The commonest of them is Juncus balticus littoralis, which exhibits the usual strait lines of growth, such as is shown in fig. 12, page 27. A few Juncus alpinus insignis occur as relics where the Potentilla has successfully invaded the Triglochin palustris association. The later plant also may remain as a relic but it is less liable to persist.

List of the Species of the Potentilla anserina Association.

f Potentilla anserina
 sr Juncus balticus littoralis
 r Juncus alpinus insignis
 r Triglochin palustris
 iSalix syrticola
 iCalamovilfa longifolia
 iPanicum virgatum
 iPopulus deltoides
 iSalix longifolia

(f = facies, s= secondary species, r = relic, and i = invader)

Potentilla in beaches which are being destroyd.

Heretofor the Potentilla association has been treated with respect to locations in which the fysiografic forces are constructiv. There now remains for consideration the areas in which those forces are destructiv in effect, as in the region from Winthrop Harbor to Kenosha. The sand plain there is normally bounded on the lakeward side by a very low ridge of a very dense growth of Juncus balticus littoralis as has been mentiond befor. Between the sand plain association itself and the Juncus is a narrow tension associ-

ation of Potentilla anserina. Shown in profile it appears thus. See fig. 16. In the course of the destruction of the shore, as has been

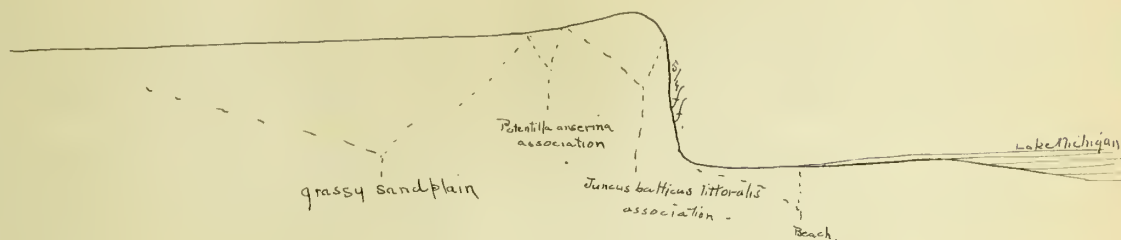


Fig. 16. A profile of the beach at Kenosha, Wisconsin as it appeared a few years ago.

mentioned above, there is exposed an area of open sand between the sand plain and the relic dunes. This is shown in fig. 13. For the most part this area is devoid of plants but in slightly sheltered places Potentilla comes in and spreads out radially, forming mats a few meters in width and several meters in length. The leaves are usually half buried and the runners can scarcely keep above the sand. It may be for this reason that here the internodes of the runners are so short. With it are seldom any secondary species. At the edge of the grass on the sand plain (fig. 13.) is a well developed association of Potentilla and mixt with it are Sporobolus cryptandrus and Cenchrus carolinianus. This makes a denser vegetation during the growing season than the grassy sand plain itself shows and effectually prevents any blowing during that period, thus protecting the grassy plain. During the winter when the sand is rendered mobil with the dying of the Potentilla a general southward movement of the sand takes place in sufficient amounts to be noticed from year to year.

The Dune Associations.

Leaving the beach formation the dune formation is next at hand. This has been so frequently and so well described (Cowles 1899, etc) that it is hardly worth while to give more than a brief summary of its characteristics before dealing with its associations. The essential conditions for dunes are wind, dry mobile sand and a nucleus to allow the sand to accumulate. (confer Warming 1909:263)

Ecological Characteristics. (confer Cowles 1899:106-111)

The sand dune is a very xerophytic habitat because of the agencies that increase transpiration such as the intense light and heat, and the strong winds. The water supply for sanddune plants is deficient because water passes through sand very readily and but a small amount is retained in it. To this may be added the low nutritive value of sand. On account of the insolubility of the sand grains and the easy access of air, organic matter which would otherwise form humus is rapidly oxidized. Water continually passing through the sand washes away even the less soluble food constituents. (Livingston 1903:14) A sand dune, however, is not dry throughout. The sand to within a few centimeters of the surface is moist. The layer of dry sand which acts as a very good non-conductor of heat prevents the entire desiccation of a dune. Because of this, vegetation there is possible.

Adaptations of the Vegetation.

The characteristic adaptation of sand dune plants is found in the extreme development of the root system in comparison with the aerial parts. To meet the constant shifting of the sand which may uncover the roots they are capable of producing adventitious shoots. Because of this the plant can sometimes move a considerable distance in keeping pace with the sand. Sand dune plants usually cover quite

a little ground and thereby serve as a protection against the blowing of sand from their roots. The grasses that inhabit the dunes are perennials and they are frequently tufted. The mere presence of some of these grasses on the upper beach may often be the starting point of a dune.

The aerial parts are clearly developed in response to the extremely xerofytic habitat. The leaves are firm in texture with stomata well protected by the position of the leaves, or by a protecting covering of hairs. Often the leaves are long and narrow and curled or folded to reduce transpiration. The inflorescence is protected in the upper sheaths until it is virtually fully ready for pollination. As nearly all of the dune plants bloom in spring before many insects have appeared, they are usually anemophilous.

Plants as Dune Builders. (confer Cowles 1899:175 et seq.)

Plants may live on a dune and yet add nothing to the life of the dune. They will accumulate sand during a season and form miniature or embryonic dunes but as soon as the plants die down in autumn the sand is again mobile. Such dunes very seldom last during the winter, although many of them are formed during the growing season. They are the "annual dunes" of Cowles (1899:177). To make a dune endure from season to season it must be fixed by perennials, particularly of the group known as sandbinders. Such plants, as is well known, have considerable ability to prevent sand from shifting due to a persistence of the vegetative parts in winter. For a dune to grow larger the sandbinder must be able easily to respond to changing conditions. It must not be killed by exposure of its root system nor by burial of its stem. To make the dune more extensive it must be able to spread radially by rhizome development, thereby developing the dune in expanse at the same time that the upward growth of the stems is developing it in

altitude.

Location in the Beach Area.

The sand dunes occur a little beyond the limit of winter wave action. They are more general in occurrence and better developed in constructive beaches. Nowhere in this region are sand dunes well developed. This is because the prevailing winds are westerly, while the lake from which the sand must come, is to the eastward of the beach. The largest dunes are about four meters high. They are protected from westerly winds by woods of pine or oak. Towards the northern and southern parts of the area where there is no protection from winds the dunes are seldom more than four decimeters in height. All but one of the dunes in this area are fixed dunes, either permanent^{en}ly or for a season only. Travelling dunes, such as occur along the southern and eastern sides of Lake Michigan are absent because the prevailing westerly winds merely take away any loose sand and carry it back into the lake. The one travelling dune is 9. meters high and is protected from westerly winds by oak woods. So in order to have any permanent dunes whatsoever the sand must be fixed by vegetation.

Dune Associations.

The different dune-forming plants give a more or less characteristic appearance to the dunes on which they occur. The dune former is the all important plant in the dune associations. Only a very few other species are capable of withstanding such a severe habitat. Consequently the dune associations are poor in species. As soon as the pioneer species begin to accumulate humus invaders appear and assume possession while the pioneers advance onward, in general, towards the lake. The process is, however, very slow and is greatly hindered by severe wind storms and tidal waves.

Dune associations are usually independent of one another and dune complexes are bilt up in part by the growth of the individual dunes. When this occurs succession take place which lead to the formation of the climax dune vegetation, as the Juniperus dune may be cald.

Calamovilfa Dune.

The sandbinding grass, Calamovilfa longifolia, plays the most important part in initiating new dunes on the upper beaches. This grass is a most efficient sandbinder and it will commence its growth under more adverse conditions than will any of the others. The root system is extensiv and forms a very dense tangle as is shown on the left in fig. 17. This plant always grows in tufts and as soon as the



Fig. 17. Washt away beach near Camp Logan, Illinois. showing exposd root of Calamovilfa longifolia on the left and of Cornus stolonifera on the right. September 4 1909.

leavs appear sand begins to be caught around the stems and lower leavs. The dune soon takes the shape shown in fig. 18. From the



Fig. 18. *Calamovilfa* dune at Beach, Illinois.
July 19 1909.

windward side the dune slopes quite gradually up to the highest point in the center of the clump from which the slope is more gradual down to the leeward. After severe wind storms the leeward trail may be over a meter in length. A change of wind, however, soon changes its position.

During the winter the dead standing stems with their leavs protect the dune in a measur from ordinary winds and storms. On the more open upper beach this protection is inadequate and the return of the growing season shows the sand to be level with some exposed roots to show the former location of the *Calamovilfa* dune. But a short time is needed to reconstruct the dune when the growing season

is once commenced. In less exposed situations the dunes persist over winter.

The Calamovilfa dunes are a conspicuous feature of the vegetation of the lake shore in the central part of this region, yet the dunes are never large in size. They spread radially quite easily but they do not grow very much in height. A Calamovilfa dune a meter in height is uncommon. The usual altitude is from three to six decimeters. Higher dunes are often formed by plants whose ecesis can be accomplished in a Calamovilfa dune but could not have been on the normal upper beach.

The outcome of the growth of these dunes is usually the formation of a ridge running parallel with the line of wave action. As additional ridges are built up nearer the lake, the Calamovilfa remains as a relic along the crest of the ridge. In such places it sometimes exhibits the growth form known as fairy rings. Succeeding associations, however, finally bring about its disappearance. The secondary species of this association are very few in number and in general unimportant in value.

List of the Species of the Calamovilfa longifolia Dune.

- f Calamovilfa longifolia
- i Populus candicans (young)
- i Elymus canadensis
- i Andropogon scoparius
- i Petalostemum purpureum (some)
- i Prunus pumila
- i Salix glaucophylla
- i Vitis vulpina (one plant 3.5 meters in length on one of the dunes.)
- i Quercus velutina (rare)

Ammophila arenaria Dune.

Because there is so little sand carried from the lake, this association of dune plants is very scarce in this region. Ammophila is a plant that grows best where there is an abundance of blowing sand. In such situations it builds dunes to a height of several meters. In this region the Ammophila dunes are in no case more than a meter in height. The dune has a very gradual slope which is steeper on the landward side. The plant spreads in lines and does not form clumps as Calamovilfa does. The Ammophila has the greatest ability of sand-binding grasses to grow upwards with the accumulation of the sand. At the same time the aggregation is so open that it permits the sand to be carried back into the lake almost as fast as it is accumulated by the plant. This is just the opposite to the Calamovilfa dunes, where the close bunching of the grass and the usually persistent dead leaves at the base of the stem permit a more prominent heaping up of the sand.

Ammophila dunes are pioneers of upper beach vegetation but they will not commence so near the drift beach as will the Calamovilfa. On the other hand, Calamovilfa can capture the Ammophila dunes and replace the plants by which they were formed.

The Ammophila dune association is so poorly developed in this area that an adequate description of it is not possible from the data at hand. An extended description is given in Cowles' account in his paper on "The Ecological Relations of the Vegetation on the Sand Dunes of Lake Michigan (Bot. Gaz. 27:179-181). The secondary species that occur have scarcely anything to do with the growth of the dune. They merely represent beach species, whose seeds have been lodged among the Ammophila stems. Lathyrus maritimus is the most abundant and best developed. Its procumbent stems trail in and out

between the *Ammophila* stems for several decimeters. It, as well as the other secondary species occur just over the crest as viewed from the lake. The main part of fig. 19 is occupied by an *Ammophila* dune.



Fig. 19. Part of the beach near Beach, Illinois, showing an *Ammophila* dune in the foreground, a *Salix glaucophylla* dune on the right and a *Populus candicans* dune in the background. September 11 1909.

List of the Species of the *Ammophila arenaria* Dune Association.

Ammophila arenaria
Calamovilfa longifolia
Lathyrus maritimus
Euphorbia polygonifolia
Xanthium commune
Potentilla anserina
Prunus pumila
Salix longifolia
Euthamia graminifolia

Salix syrticola Dune.

In the southern part of the region occur the low fringing dunes which are tenanted by the willow, Salix syrticola. They are low flat dunes just a little out of reach of the winter storms. They tend to grow in width rather than in height and consequently this association is one of the first to make a permanent vegetation on the beach.

The plant itself grows as a straggly bush, sufficiently dense apparently to cover the ground with vegetation but not to prevent a strong wind from carrying away sand that may have accumulated at the bases of the stems. Because of this the height of these dunes depends upon the amount of protection that they have from the westerly winds. From Waukegan to the area of the pines where there is no such protection the Salix syrticola dunes are from two to four decimeters in height. When protection is afforded by the pines the dune will keep pace with the blowing sand to the height of about three meters. Only a few plants of this willow, however, are able to continue their growth upward with the accumulating sand and the ridge is broken up in a dune complex. In it only a few of the dunes belong to this association.

At the southern end of the area, where the beach is low and very level, seeds of this willow germinate in the Juncus balticus littoralis association. The plants are larger in the Potentilla association and reach their average development in size on the low ridge just back from it. This ridge is the typically developed Salix syrticola dune. In this part of the region occur the majority of the secondary species, virtually all of which are relics or invaders.

A little further north where the beach is still level, the sloping upward all the way from the lake, the Salix syrticola dune, composed of only the facies, occupies the lakeward front. There is more blowing sand and each plant is more or less buried. The plants advance lakeward as fast as they can by means of their underground stems.

List of the Species of the Salix syrticola Dune Association.

- f Salix syrticola
- r Potentilla anserina
- r Juncus balticus littoralis (few)
- s Elymus canadensis
- r Xanthium commune
- s Salix longifolia
- rs Calamovilfa longifolia - (not common - usually occurs as a hill-lock built up 1-2 dm above its surroundings)
- i Andropogon scoparius (rare)
- s Populus deltoides 1.3 meters
- s Lathyrus maritimus (not common)
- i Euthamia graminifolia
- s Salix glaucophylla
- i Potentilla fruticosa

Prunus pumila Dune.

Entering into the composition of the dune complex to the eastward of the pines are several steep mounds surrounded and capt by Prunus pumila. This plant is a very efficient dune holder but no examples of stages in dune formation by it were found. The occasional presence of a Calamovilfa at the summit indicates that, in this region at least, Prunus pumila dunes are formed by the replacement of a dune originator. The fruit of the Prunus is eaten by a few species of birds among which are two, the song sparrow and tree sparrow, which occasionally frequent the clumps of Calamovilfa. Once the Prunus is started sand can be easily held by its dense growth. This is too dense for secondary species but where there is a

break a young Populus candicans may be present. Occasionally on one of these dunes there is along side of the Prunus pumila a bush of Cornus stolonifera which has the same habit as the Prunus. The presence of the Cornus is due directly to birds as this species is avevectant. The robin (Planesticus migratorius) seems to be the most probable agent as it has been observed eating the druplets and has been seen on the Prunus bushes, while drying after a bath in the lake. The distance traversed amounts to nearly a kilometer.

On account of the dense growth of this Prunus a Prunus pumila dune remains an isolated unit in the dune complex. In case of the death of the Prunus the sand which has accumulated again is mobil. and a few wind storms will cause the disappearance of the dune.

List of the Species of the Prunus pumila Dune Association.

- f Prunus pumila
- r Calamovilfa longifolia (not common)
- f i Cornus stolonifera (infrequent)
- s i Populus candicans (uncommon)

Populus candicans Dune.

In a restricted area between Beach and Zion City occur the dunes of maximum height. They are surmounted by narrow groves of Populus candicans. The tree trunks show no evidence of being buried. On the other hand, at the ends of the association there is every evidence to show that sand is being blown lakeward and to a slight degree landward upon the adjoining prairie or heath as the case may be.

Populus candicans is a plant which facilitates the growth of a dune but it does not originate them. The plants of the dunes are all average sized trees. The young plants, when they occur on dunes at

all, occur in with other species, especially Prunus pumila. By far the greater number of the young plants occur in the heath and Laciniaria scariosa associations. There they grow and by their shade the density of the ground flora is reduced. As the latter disappears sand is set free to the wind, which may then form a ridge dune. These dunes are quite similar to those found by Jennings (1909:338) on Presque Isle. There, however, it is Populus deltoides that is the dune nucleus. Populus deltoides occurs in the Beach region along the margins of either temporary or permanent lagoons but the individuals are separated and do not show a tendency to become dune formers. This dune is shown in the background of fig. 19.

List of the Species of the Populus candicans Dune Association.

- f Populus candicans
- s Prunus pumila

Elymus canadensis Dune.

Dunes of this type are infrequent and of little importance in this region. They are low (3 dm) with a rather steep front towards the lake and a very gradual slope away from the lake. The crest is occupied by Elymus canadensis and the slope by that species mixt in with Sporobolus cryptandrus and Artemisia caudata. Westward of these dunes is an open area from which sand has been removed to lake level. The Elymus dune keeps the lake from flooding the area and the spring rains from running into the lake.

List of the Species of the Elymus canadensis Dune Association.

- | | |
|----------------------------------|------------------------------------|
| f <u>Elymus canadensis</u> | r <u>Cakile edentula</u> |
| s <u>Sporobolus cryptandrus</u> | s <u>Salix longifolia</u> |
| s <u>Euphorbia polygonifolia</u> | s <u>Cycloloma atriplicifolium</u> |
| s <u>Euphorbia corallata</u> | s <u>Asclepias syriaca</u> |
| s <u>Rhus toxicodendron</u> | s <u>Panicum virgatum</u> |
| s <u>Artemisia caudata</u> | |

Juniperus Dunes.

When a small dune has been formed by some of the sandbinding plants such as Calamovilfa, Prunus pumila and less frequently Andropogon scoparius, either one or both of two species of Juniperus may come in and replace them; forming what is called the Juniperus dune. A heath plant, Arctostaphylos uva-ursi may be present but shows a preference, in this region, for the sides rather than the crests of dunes. These three plants, Arctostaphylos and the two species of Juniperus, seldom intermingle but form adjoining families in the same association. There seems to be no evidence to show whether one Juniperus or the other appears on a dune first. Juniperus horizontalis, however, is by far the more abundant on the dunes, altho Juniperus ^{*communis depressa*} nana are just as well developed. It is characteristic of Juniperus dunes to have the sides as well as the crest densely matted with vegetation. Juniperus horizontalis is especially adapted for this, as fig. 20 shows.



Fig. 20. Section of a Juniperus horizontalis dune, Beach, Illinois. July 19 1909.

The prostrate stems form a dense matwork of vegetation both winter and summer in which considerable sand is retained. The juniper itself easily keeps pace with the infiltration of sand, and by growing outward permits the dune to grow radially at the same time that it is growing in height. Figur 20 shows a place where the wind is demolishing the dune. The *Calamovilfa* which appears midway at the left was carried there when the crest gave way to undermining. These dunes reach an altitude of 3-4 meters. Higher growth is difficult because most of the sand-blowing winds are parallel rather than at right angles with the axes of the dunes.

Juniperus nana^{*communis depressa*} dunes are less frequent and more gently sloping than those of *Juniperus horizontalis*. Their sides are much more frequently blown away by the wind. In view of this, unless the sides are fixed with *Juniperus horizontalis* or *Arctostaphylos*, a *Juniperus nana*^{*communis depressa*} dune is liable to be blown away and a break formed in the line of dunes thru which the wind carries sand onto the heath behind them. At the same time, adjoining dunes of *Juniperus horizontalis* are undermined until the exposed side becomes covered with vegetation.

The junipers are the most efficient dune-builders in this region, but they can only build dunes where their westward^{side} is protected from the prevailing winds. Normally the junipers are mat-formers in the heath association, which will be treated of later, but in the presence of blowing sand they meet the change of condition by becoming dune-builders. These dunes must be closed associations, since any open place on them would be seized upon by the wind and the removal of the dune effected. The vegetation being dense and completely covering the ground secondary species, with the exception of relics on the crests, do not occur. Of these relics which were the nuclei about which the dune originated *Calamovilfa* is the most frequent with

Prunus pumila second, a very few plants of Andropogon scoparius, and but one of Cornus stolonifera.

List of the Species of the Juniperus Dunes.

- f Juniperus horizontalis
- f Juniperus (nana) communis cf. var.
- f Arctostaphylos uva-ursi
- r Calamovilfa longifolia
- r Prunus pumila
- r Andropogon scoparius
- r Cornus stolonifera

Miscellaneous Dunes.

In addition to the associations given above which occupy about 97 % of the dune areas, there are isolated dunes each one of which is characterized by a rather definit association of plants. In each case the plants are more typical of other associations but they grow within the range of blowing sand and consequently dunes are formed about them.

Populus-Salix Dune.

But two well markt examples of this dune association, which has been described by Jennings from Presque Isle, occur in this region. In both cases the dunes are low and are formed on the eastern border of the Andropogon scoparius gravel plain to be described later. One of these dunes was occupied by the following species:

Populus deltoides (2 meters in hight),
Salix glaucophylla,
Salix syrticola (a relic),
Calamovilfa longifolia, and
Potentilla fruticosa.

The other had the following plants:

Salix syrticola,
Juncus balticus littoralis,
Elymus canadensis,
Salix longifolia,
Populus deltoides and
Potentilla anserina.

Once in a while a well developed Salix glaucophylla or Salix longifolia will form miniature dunes. The branches bend down to the ground and beneath their shelter sand and debris gradually accumulate. In this debris are seeds of various plants, notably the winged ones of species of Populus and Salix. In rifts where sufficient light may be had a number of plants which could not get a foot hold on the open sand may obtain a start. The following species were observed:

Fragaria virginiana,
Arabis lyrata,
Erigeron philadelphicus,
Potentilla anserina,
Panicum virgatum,
Artemisia caudata,
Zizia aurea,
Impatiens biflora,
Taraxacum erythrospermum, and
Melilotus alba.

Seedling *Populus deltoides* are also present which indicates that a *Populus-Salix* dune is being formed. Populus deltoides itself when growing on the sand in this region does not form dunes. Species of *Salix*, which afford a ground protection to retain sand, at the same time serve to catch *Populus* seeds. Normally a thicket should be formed but as yet the ground is too poor in food materials to support the mesofytic species of the thicket association.

Salix glaucophylla Dune.

A few dunes formed entirely by this plant were observed near Kenosha, one of which is shown in figure 21. The dunes are low and elliptical in shape, while the major axis, which runs north-northwest, is about twice as long as the minor axis.



Fig. 21. *Salix glaucophylla* dune. Near Kenosha, Wisconsin. November 23 1909.

Panicum virgatum Dune.

During the growing season a small dune may be bilt up around a tuft of *Panicum virgatum* but ~~such~~ dunes are temporary as they do not withstand the winter. As a rule these dunes hav no other species than the facies upon them, but occasionally *Arabis lyrata*, *Salix syrticola*, *Poa compressa* and *Poa pratensis* occur around the edges of the tuft of *Panicum*.

Andropogon scoparius Dune.

This grass normally grows on level ground but it will come in on the sides of dunes originated by sandbinders such as *Calamovilfa*. With the death of the *Calamovilfa*, *Andropogon scoparius* is left in full possession. It is efficient in holding the dune but further growth of the dune ceases. Such dunes are at most five decimeters high.

Near Waukegan, in a place where sand had been freed of gravel, there was left a gravel mound about two meters high. The summit and

nearly all of the sides are tenanted by Andropogon scoparius stools, in the interstices of which are several sand plants, as, for example, Arabis lyrata, Petalostemum purpureum, Lithospermum gmelini, etc. It has the general appearance of a developept dune, such as Jennings has on Presque Isle, but the mode of its origin is easy to perceiv.

Populus-Salix-Cornus Thicket Dune.

This dune-like condition exists near the state line where the lake is attacking the shore. It is not a developept dune but it is the result of sand being blown in upon the Populus-Salix-Cornus thicket which is being cut into by the lake. The thicket reacts to the in-blowing sand, however, by becoming a dense mass of liana-entwined vegetation with an advance gard of Salix longifolia to check the incoming sand. Such thickets are well nigh impassible on account of the network of lianas, which in this area are Vitis vulpina and Psedera quinquefolia. Salix longifolia easily keeps pace with the blowing sand but succums to the violence of wave action as the shore is gradually washt away. With the Salix longifolia are associated a few prairie plants the roots of which are in sod buried beneath the sand. A few of the commonest are Lythrum alatum, Panicum capillare, Trifolium repens, Verbena hastata, Verbascum thapsus, Polygonum lapathifolium, Cenchrus carolinianus and Cirsium arvense which in this and other places forms small dunes five to six centimeters in hight.

alba Betula papyrifera Dune.

But two examples of this kind of dune occur in this area one of which is shown in fig. 22.



Fig. 22. *Betula papyrifera* dune near Kenosha, Wisconsin.
November 23 1909.

Relic Dunes.

Dunes form one of the typical stages in the construction of beaches and they may also be one of the stages in the destruction of a vegetated beach. There are termed "relic dunes". Fig. 13 shows a group of such dunes. The vegetation north of Winthrop Harbor is bordered on the lakeward side by a low ridge which supports a very dense growth of Juncus balticus littoralis. When the lake begins to cut into the beach it washes away sand from the Juncus, leaving an exposed bluff of densely intertangled roots. In weak spots the waves are able to wash their way entirely thru the ridge of Juncus to the grassy plain beyond, which is easily destroyed as far as the waves have power. In places the Juncus is left as a mound with its sides perpendicular and densely coated with exposed roots.

This is an early stage of a relic dune. One of them is shown in detail in fig. 23. As continued wave action goes on the onwash and the backwash of the waves in combination with the wind reduce the dune from the appearance of "A" in fig. 13 to that of "C" in which



Fig. 23. Near view of a relic dune at Kenosha, Wisconsin. Vegetation entirely of *Juncus balticus littoralis*. Nov 23 1909

the sides are sloping. These summer secondary stages look very much like ordinary dunes except that they are more or less coated with exposed roots. In the course of time the dune is entirely washed away. During the winter the disruptive power of freezing water is an important agent in the breaking up of the dunes. The effect of a severe frost following a heavy rain upon one of these dunes is shown in fig. 24.

These dunes are prominent features of the vegetation of the beach from the state line to Kenosha. With the *Juncus* are associated a few plants of relatively little importance, such as *Sporobolus*



Fig. 24. A relic dune near Kenosha, Wisconsin, showing the disruptiv power of freezing water. Nov 23 1909.

cryptandrus and Cornus stolonifera. Besides the Juncus only one plant forms relic dunes, namely, Juniperus ^{*communis depressa*} nana, a relic dune of which is shown at "D" in fig. 13. Its sides are as steep as those of the Juncus and the most of the vegetation is on the lakeward side. The sand that accumulates somewhat in the rear of the dune is not washt away rapidly because the dune is so near the limit of wave power. During the course of the next few decades there will be eight or ten of these Juniperus relic dunes, formd by both Juniperus ^{*communis depressa*} nana and Juniperus horizontalis.

Man-made Dune.

In order to protect the golf grounds at the southern edge of Kenosha from blowing sand, a long dune about 2 meters has been contructed and fixt by the planting of willows upon it. This dune is

shown in fig. 25. For the most part it is tenanted by species of



Fig. 25. Man-made Dune, Kenosha, Wisconsin. Nov 23 1909.

Salix, which include among others, *longifolia* and *glaucophylla*. The bushes form a fairly dense tangle about 1.4 meters in height and mixed with them are individuals of *Elymus canadensis*, *Monarda punctata*, *Linaria vulgaris*, *Artemisia caudata* and *Achillea millefolium*. In a few places the dune is fronted by *Juncus balticus littoralis*. Upon the west side of the dune the sodded ground extends to its base. The south end is not sufficiently well protected and consequently the wind is undermining the willows to some extent.

Travelling Dune.

For the reasons given befor this kind of dune is not a featur of this region, in fact the following illustration shows the only one that is present in the area. Its hight above the lake level is 9 meters and a few oaks hav been partially coverd by it.



Fig. 26. Travelling dune. Kenosha, Wisconsin.
November 23 1909.

Artemisia-Panicum Association.

This association which is so wide spread on Presque Isle and is of general occurrence along the shores of Lake Michigan is but poorly represented in this region. A majority of the species mentioned by Cowles (1899:168 et seq) occur upon it but from 40 to 60 % of the area is taken up by invading plants of the bunchgrass association which borders and is extending rapidly into it.

Location and Physical Characteristics.

The area which stretches back from the fringing dunes is largely composed of sand whose grains are about 0.5 mm in diameter. The relative amount of sand decreases in going away from the lake. At the same time the relative amount of gravel increases. The change is uniform, though gradual. The Artemisia-Panicum association occupies the sandier parts and thins out quite rapidly as the amount of gravel increases. The reverse of this is true with respect to the bunchgrass association. The sand is somewhat mobile but not much so because of protection by the fringing dune and by the vegetation of the bunchgrass association. Water is near the surface and is easily available, but food materials dissolved in it are low in amount. The aeration of the sand, aided by the relatively large spaces between the grains, and the sudden changes of temperature, is very thorough, which leads to rapid eremacausis and consequent absence of humus.

Ecological Characteristics.

Except for the absence of wave action there is very little difference in ecological characteristics between this area and the middle beach. The habitat is dissofytic, because the underground parts of the plants are in mesofytic to hydrofytic condition according to the water content of the soil, while the upper parts are sub-

jected to rather severe xerofytism. The desiccating effect of the wind and sun are met with by means of adjustments in the plant structure (confer Kearney 1900:276-280)

The Association.

The association itself is an open one in which about 30-40% of the area is vegetated. From 30-50% of the vegetation is occupied by the facies, Artemisia caudata, which gives a grayish tone to the soil. Cowles (1899:168) says that the most characteristic plants are two species of Artemisia, A. caudata, and A. canadensis. In the Beach region only Artemisia caudata is present. In a similar area near Rogers Park, Chicago a few miles south of this both species occur. The other facies, Panicum virgatum, that Jennings has at Cedar Point and Presque Isle is, in this region, of relatively little importance in this association, tho it occurs not infrequently. Its place is taken by Sporobolus cryptandrus, which grows in clumps somewhat like a bunchgrass. Its growth habit is illustrated by fig. 27. This plant, however, is more characteristic of blowouts.

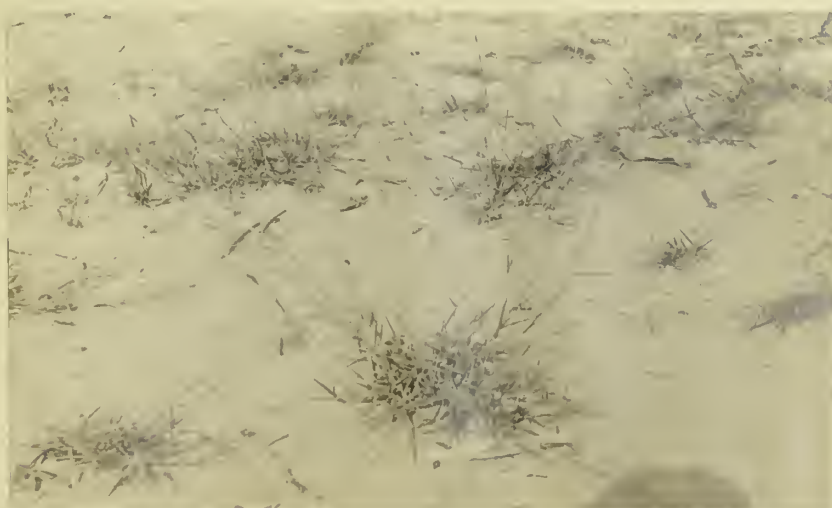


Fig. 27. Sporobolus cryptandrus, illustrating growth habit. Winthrop Harbor, Illinois. August 30 1909.

These three character species occupy about 95% of this area in typical situations of this association. Typical examples are, however, rather rare in this area. The best develop of these is about a kilometer north of the Lake County pest house. There this association is 8-10 meters in width and approximately 20 meters in length. Usually tho the invader, *Andropogon scoparius*, gives a decided character to the appearance of this association in which it grows at intervals of 2-3 meters.

Of the other species which Cowles has listed as characteristic of this association, but four specimens of *Cirsium pitcheri* have been found. A very few specimens of *Lathyrus maritimus* grow in here, while this plant is commoner on the lee side of the *Ammophila* dunes. *Euphorbia polygonifolia* is fairly abundant tho of course it cannot be so characteristic as on the middle beach. *Oenothera biennis* does not occur in this association and *Agropyrum dasystachyum* does not occur in the region at all.

Secondary species occur more or less thruout the association, but are most abundant nearer the margins where the prairie element has started to invade. They are usually not numerous but frequently, because of their bright colored flowers, seem almost to be floristically dominant. Such plants give to the associations what is termed seasonal aspects. The late-vernal and estival aspects are given by the orange flowers of *Lithospermum gmelini*. This plant has a very long (3 meters or more) bulky tap root from the crown of which grow many stems. The stems are more or less spreading and give a general hemispherical appearance to the plants. *Lithospermum*, however, does not occur so frequently in the typical parts of the association, as it does in the tension lines which the bunchgrass is rapidly pushing outwards. The serotinal aspect is characterized by the

blooming of the yellow flowers of Solidago nemoralis. This plant also is much more characteristic of the bunchgrass sand areas. The autumnal aspect is given by the blooming of Sporobolus cryptandrus and of Artemisia caudata.

In addition to those secondary species that give character to the different seasonal aspects there are a few other species typical of different associations that are of importance in showing the past stages and in indicating the future successions.

List of the Species of the Artemisia-Panicum Association.

- f *Artemisia caudata*
- f *Panicum virgatum*
- f *Sporobolus cryptandrus*
- i *Andropogon scoparius* (at intervals of 2-3 meters)
- s *Cirsium pitcheri*
- s *Lathyrus maritimus*
- s *Euphorbia polygonifolia*
- s i *Lithospermum gmelini*
- s i *Arenaria stricta*
- i *Petalostemum purpureum* (arenarium)
- i *Solidago nemoralis*
- i *Liatris scariosa* (a few)
- i *Potentilla fruticosa* (one plant)
- i *Poa compressa*
- i *Aster dumosus*
- s *Cycloloma atriplicifolium*
- i *Arctostaphylos uva-ursi* (few)
- s *Equisetum hiemale*
- s *Arabis lyrata*
- s *Prunus pumila*
- i *Juniperus horizontalis* (a few small patches)
- r *Calamovilfa longifolia* (few)

Bunchgrass Association.

Andropogon scoparium consociates.

Location and Physical Characteristics.

Immediately westward of the usually poorly developed Artemisia-Panicum association lies a more or less gravelly or pebbly area, whose vegetative appearance is characterized by the stools of Andropogon scoparius. The physiographic appearance shows every indication that the area was at one time part of the beach, later it was covered with drifting sand and is now being gradually uncovered by the very slow movement of the fringing dune towards the lake. Because of its past history it is given the name "fossil beach", in allusion to the corresponding geologic term. The pebbles and gravels of which its surface is composed are all well rounded and flattened, clearly indicating the former presence of surf. The largest of these pebbles are about 15 cm in diameter and 2-3 cm in thickness. Almost all of them are composed of granites, quartz and less frequently shales and sandstones. From between them the wind has gradually removed the mobile sand which is taken to the fringing dune. So much sand has been removed that now the pebbles are very frequently perched upon little hillocks a few millimeters in height. Investigation has shown that the sand in these little "tees", to use a golfing term, is more or less damp even to the surface. The pebble itself affords the tee protection from the drying effect of the direct rays of the sun. In the protection thus afforded spiders as well as some small insects spend the hotter part of the day. Rain drains very rapidly through this soil.

Ecological Characteristics.

What has been said under the ecological characteristics of the

Artemisia-Panicum Association will apply here also. The habitat is dissofytic but the above ground part is not quite so xerofytic. Humification rather than eremacausis which the rule in the Artemisia-Panicum association is beginning to take place. Lack of sufficient food material seemd to be the most potent cause for the openness of the vegetation.

The Association.

The bunchgrass association is a typical prairie one and of course is far better represented in areas farther west. The bunchgrass association of the prairie vegetation is the pioneer both of the prairie and the forest type of vegetation. It can maintain itself on fossil beaches and redily invades the upper beach. Meanwhile it adds humus to the soil and prepares the way for successions to a more advanced type of prairie or to a heath or to a forest. Which succedes depends upon several factors among which are proximity, means of dispersal. of the invaders and the ability of the invaders to effect ecesis. The association itself has for its facies a grass which grows in tufts or bunches. According to the specific identity of the bunchgrass, the association is divided into consocieties. Some of these hav been described for southeastern South Dakota by Harvey (1908) and for the Illinois sand areas by Gleason (1910). Of these consocieties only one appears as a definit part of the region in this area. That is the *Andropogon scoparius* consocieties which has been described as a pioneer of ^{prairie} vegetation by Harvey (1908:287). There are, however, clear indications that there hav been other consocieties represented which are now succeded by forest associations. Some of the bunchgrasses which were once facies are now relics, living as secondary species under the *Quercus velutina*.

The association itself is open, since but 25-40% of the area is

vegetated. Approximately 90% of the vegetated area is occupied by the facies, Andropogon scoparius. The secondary species may be more numerous but they are interstitials that occupy very little surface. Fig. 28 gives the general appearance of the association thruout the year and shows the manner of growth that the facies exhibits.



Fig. 28. Andropogon scoparius bunchgrass prairie near Beach, Illinois. August 17 1909.

Andropogon scoparius.

As shown in fig. 28 - this grass is a typical bunchgrass. The dead leaves remain over winter and until the new leaves grow. They do not seem to be capable of retaining blowing sand and so this grass is not a dune former. It can fix dunes, however, but not until the dune has been bilt up by some regular dune former. The plant spreads radially but very slowly as it does not hav runners. This continues until the diameter of the bunch or stool is from 3.0 to 3.5 decimeters.

It does not often grow larger than this. Occasionally bunches are to be found in which the central part is dead, the circle of stems around it forming a small fairy ring. (Gleason 1908:88) Other plants become established in the center and tend to lead to the gradual replacement of the bunchgrass. Arabis lyrata and Potentilla fruticosa, an invader, are most frequent in this rôle. Others that^{hav} been found so situated are Arenaria stricta, Oenothera rhombipetala, Sisyrinchium sp?, and Artemisia caudata. In this area the bunches themselves are always separated, usually by about 8-9 decimeters. The more pebbly the area, the greater is the tendency for the bunches to be nearer together but seldom closer than 5 decimeters. The bunches which are invading the Artemisia-Panicum are developed just as well as those in the bunchgrass itself.

The area between the bunches is occupied by interstitials which, however, are not sufficiently abundant to prevent the sand from giving the general color tone. In point of numbers, Arabis lyrata is most abundant. When it is well in bloom in May, the white flowers considerably lighten the general dull gray tone of the dead leaves of the facies. This may be termed the vernal aspect. Next to secure color prominence is Lithospermum gmelini which blooms during Jun and July. This plant is not actually abundant in the typical part of the association but its manner of growing and the abundance of the brilliant orange flowers are easily misleading in determining the importance of this species in the association. It is most abundant near the tension line or towards the outside of the association. Altho this plant has neither dune forming nor dune fixing abilities, it seems most at home where this association is invading the lower parts of the dune complex near Beach. There it occurs at frequent intervals either in the lower places or on the sides of the dunes

with apparently no discrimination. Occasionally it is present on the tops of some of the smaller dunes. Seedlings of it can be found in various situations tho they are most frequent in depressions. The root system of Lithospermum gmelini can withstand a moderate amount of either burying or uncovering, so this plant can easily tenant the dune complexes of this region which are protected from the westerly winds by the area of the pines. It seems to fulfill the position of pioneer to the Andropogon scoparius consociates of the bunchgrass association. Cycloloma atriplicifolium, Petalostemum purpureum and Arenaria stricta play the same rôle but to a less markt degree.

The estival aspect of this consociates is characterized by the blooming of the Andropogon scoparius itself and of the interstitial Petalostemum purpureum. The latter species, which is typically a prairie one, exhibits markt xerofytic adaptations in several particulars -- so much so that a detaild description is necessary and it is here given in the form of a table:

Prairie plant(normal)		gravel plant.
Roots	Tap root	larger and more bulky tap root.
Crown with	a few upright stems	many (20-38) radiating stems
Stems	stout and upright	shorter, wiry, divaricate -5° to 45°.
Leavs	divaricate, lanceolat-trifoliolate	apprest, linear-trifoliolate
Heads	cylindric and longer	cylindric and shorter
Flowers and Fruit	no appreciable difference.	

The appearance of the sand form is very different from that of the prairie type but the differences are due to the edafic xerofytic conditions under which it grows. In places where this association has been succeded by trees which hav induced milder xerofytic con-

ditions the Petalostemum, tho still growing in nearly pure sand is about normal in appearance. Fig. 163 shows a plant of this species in which the stems form an angle of from 5° to 15° with the sand level. In some cases sand and debris have been piled up above the



Fig. 29. The manner of growth of Petalostemum purpureum in the bunchgrass association, Waukegan, Illinois. Aug 17 1909.

crown, while the sand beyond the protection of the stems has been blown away. In such places Petalostemum, when growing prone, makes a negative angle with the general level. In general the individual plants grow apart, but on the gravel where there is almost no exposed sand they grow so close together that the heads overlap and form a tangled layer about a decimeter above the gravel level. Such situations are frequent hiding places for savannah and song sparrows. The heads of the Petalostemum seem usually to be infested with a small green caterpillar, and the leaves with tent weaving larvae.

In the serotinal aspect, Petalostemum continues to dominate the more gravelly parts but in other places Solidago nemoralis comes into prominence. The bright white pappus of the fruits of both An-

dropogon scoparius and Solidago nemoralis are characteristic of the autumnal aspect. Neither of these plants loses its seeds until after the sharp winter frosts. With the return of winter the association assumes a dull gray color of dead leaves which resembles in some particulars the arid brush lands of the west.

List of the Species of the Andropogon scoparius consociates of
the Bunchgrass Association.

- f Andropogon scoparius
- s Arabis lyrata
- iPotentilla fruticosa
- s Arenaria stricta
- s OEnothera rhombipetala
- iSisyrinchium sp?
- r Artemisia caudata
- s Lithospermum gmelini
- s Cycloloma atriplicifolium
- s Petalostemum purpureum arenarium
- s Solidago nemoralis
- s Hypericum kalmianum (few)
- s Euphorbia corallata
- s iPopulus deltoides (small)
- r Salix syrticola
- r Salix glaucophylla (not common)
- r Juncus balticus littoralis (not common)
- s a moss
- r Calamovilfa longifolia (as individuals rather than bunches)
- r Sporobolus cyrptandrus
- s Elymus canadensis
- s OEnothera biennis (very few)
- s Salix longifolia
- iJuniperus ^{monosperma} nana (few)
- s Prunus pumila
- s Aster multiflorus
- iJuniperus horizontalis (few)

Sporobolus heterolepis-Sorghastrum nutans Consociates
of the Bunchgrass Association.

This consociates, which has been more widely extended in the past than at present, is quite similar to ordinary prairie. For the most part the consociates has been succeeded by Quercus velutina but in a few places between the oak ridges there still remain small characteristic areas of it. Four bunchgrasses compose its facies. The two for which it is named are the most abundant. The others are Andropogon scoparius and furcatus. The largest and most conspicuous of them is Sorghastrum nutans, which grows in tufts rather than bunches. It is, perhaps, the most persistent as a relic in the association that follows. Sporobolus heterolepis itself grows in rather good sized bunches which are usually ring-like, the open area in the center being a flat mound of blackish dirt. The stem and leaves are thin and wiry and the whole gives rather a delicate appearance. In parts of this area this grass may occupy 60% of the area. Andropogon furcatus, which grows in small bunches, aids in giving a general character to the area but it is not so important as the others. It seldom occupies more than 10% of the area but it will persist under the oaks almost as well as the Sorghastrum. Andropogon scoparius, whose bunches have already been described, occupies from 30-50% of the area. It is smaller in size and does not give so much character to the vegetation. It grows out in the open parts of the association and, while it does persist in the Quercus velutina association, it does so only in the open places. In the autumnal aspect these four bunchgrasses occupy about 97% of the area, the remaining 3% being secondary species some of which are interstitials as Arenaria stricta; others are grasses as

Spartina michauxiana and Poa compressa; and still others are invaders from nearby prairies and forests as Potentilla fruticosa and small plants of Quercus velutina. Solidago rigida and nemoralis occur but not in numbers sufficiently great to produce the usual color dominance. Other prairie plants occur but there is very little sod being formed and Quercus velutina seedlings are able to develop readily.

List of the Species of the Sorghastrum nutans-Sporobolus heterolepis consociates of the Bunchgrass Association.

(of the typical portion only)

- f Sporobolus heterolepis
- f Sorghastrum nutans
- f Andropogon scoparius
- f Andropogon furcatus
- s Panicum virgatum
- sr Sporobolus cryptandrus
- s Solidago rigida
- s Solidago nemoralis
- s Aster ptarmicoides
- s Spartina michauxiana
- iPotentilla fruticosa
- s Lobelia spicata
- s Polygonum tenue
- iQuercus velutina
- s Koeleria cristata
- s Amorpha canescens
- s Potentilla arguta
- s Anemone cylindrica
- iLiatris scariosa
- s iEuphorbia corollata
- s Comandra umbellata
- s Solidago speciosa angustata

Arctostaphylos-Juniperus Heath Association.

Following Warming, a heath may be defined as an area of low, evergreen vegetation. In Europe the heaths are composed mainly of ericaceous plants. In this area, the vegetation structure is similar but the ericaceous plants play more of a secondary part.

Location.

The heath is best developed in the part of the region near Beach, where it covers what has been a dune complex. It is becoming well developed on the present dune complex which is sheltered by the pine forest. Thence the heath extends south behind the bunchgrass until it disappears a little north of Waukegan. Towards the south its development is mostly in patches rather than a general condition. North of Zion City the heath exists only in relic patches of which there are but a few.

Physical Characteristics.

The heath usually appears as sandy ground almost entirely carpeted with low, shrubby, evergreen plants, such as is shown in the foreground of fig. 30. The color tone is dark green, especially in winter. The sand is somewhat darker in color on account of the admixture with debris and humus materials.

Ecological Characteristics.

Invading heath plants are in epharmony with the ecological conditions which they encounter. Once they become established, however, they bring about radical changes, the most important of which is the institution of humification rather than eremacausis. Blowing sand, leaves and debris are caught and held among the branches of the heaths. For this reason, if no others interfere, a heath is usually growing upward in height. Altho the ground is carpeted there



Fig. 30. Heath near Beach, Illinois. *Juniperus* in the foreground. Back of a strip of sand is *Arctostaphylos*. In the background is a tree of *Pinus strobus* and a grove of *Quercus velutina*. August 24 1909.

is still sufficient room for interstitials.

The Association.

In this area three species characterize the heath, *Juniperus horizontalis* and *Arctostaphylos uva-ursi* are of prime importance while *Juniperus* ^{*communis depressa*} *nana* is less so. The first two are essentially mat formers while *Juniperus* ^{*communis depressa*} *nana* usually forms a table, elevated 2-4 decimeters above the surroundings. *Juniperus horizontalis* forms large mats by growing radially. The runners, as the branches might be cold, take root at intervals. This results in a gradual movement of the whole plant. In the larger mats the central area is dead and in some instances has given rise to blowouts. Often, however, the center may be occupied by a normally developed *Juniperus* ^{*communis depressa*} *nana*. It is evident that this came in last because of the dead stems of the *Juniperus horizontalis* which remain under the *Juniperus* ^{*communis depressa*} *nana*, whereas the light is so excluded by the growth of the latter that no plants

will germinate or grow under it. The runners of the Juniperus horizontalis send up twigs which bear the leaves. The leaves of the season are more or less coated with a bloom which gives them a somewhat whitish appearance. The tips of the runners are elevated about 25° or 30° into the air. Should blowing sand encounter them a small ridge is built. Between these runners debris accumulates fairly rapidly and as it is not blown away during the winter it contributes to the enrichment of the soil. Many seeds also are retained and when proper conditions arise they grow and some of them take the place of the heath altogether. This Juniper, as well as the other two heath plants, has seeds which are eaten by birds, altho they are more partial to the bright red berries of Arctostaphylos. The latter plant, known as the bearberry, is of second importance. What has been said about Juniperus horizontalis applies here almost equally well. The development of the runners is not so noticeable and a greater amount of debris is retained in its denser network of branches.

The development of the other Juniperus, J. ^{Communis depressa} nana, reminds one very strongly of the development of conifers near the tree line in Lapland (Kihlman 1890). The truncated top of this plant is characteristic of all the individuals wherever they are growing. Some of these tables are a little over a meter in diameter. They vary in height from about 2 decimeters up to nearly a meter. The explanation which Kihlman found to solve the problem in Lapland has no bearing in this case, however, for it seldom happens that there is sufficient snow in winter to cover even the lowest of these tables. The explanation lies more probably in that this growth habit is a germ character of this species for in so far as evidence is at hand edaphic factors merely change the amount of growth and not its manner.

The heath plants come in on *Calamovilfa* or *Prunus pumila* dunes which they work over into *Juniperus* dunes. In the meantime the plants spread from the dune over the interdunal spaces. When these become covered or nearly so the dune complex has been changed into a heath. Blowouts occurring in the heath are in general revegetated with the heath plants rather than with invaders. This will be discussed later under the general topic of blowouts.

Secondary species in this association are not very numerous and none of them are typical of the association. They are either relics of past associations or invaders of the succeeding ones. In no case do they add to the general character of the vegetation though they may greatly change the appearance of individual parts.

This association is a transitory one of northern affinities and all the evidence goes to show that it is very gradually being driven entirely from the area. In the northern parts of this area it has disappeared already. In the central part north of the Dead Lake the *Quercus velutina* association is fairly rapidly taking its place. For a little ways south of the Dead Lake it is being slowly replaced by pine trees. Further south are the only places where the heath is reproducing itself, though at the same time the prairie is coming in from the westward more rapidly to take its place.

List of the Species of the Heath Association.

- f *Juniperus horizontalis*
- f *Arctostaphylos uva-ursi*
- f *Juniperus (nana) communis repens*
- f? *Juniperus virginiana* (one plant only)
- s *Solidago nemoralis*
- s *Petalostemum purpureum*
- r *Andropogon scoparius*
- r *Calamovilfa longifolia*
- r *Salix glaucophylla*
- r *Koeleria cristata*
- r *Salix syrticola*
- r *Prunus pumila*

r *Artemisia caudata*
 r *Juncus balticus littoralis*
 r *Sorghastrum nutans*
 i *Ceanothus americanus*
 i *Populus deltoides* (1.5 meters)
 i *Quercus velutina*
 i *Potentilla fruticosa*
 i *Aster ptarmicoides*
 i *Panicum virgatum*
 i *Populus candicans* 6 dm
 i *Liatris scariosa*
 i *Pinus strobus*
 i *Pinus laricio*
 i *Pinus silvestris*
 i *Poa compressa*
 i *Hypericum kalmianum*
 i *Aster azureus*.

a *Pyrus malus* (one plant 1.3 meters high, accidental near an abandond camp)

Pine Forest Association.

General Location and History.

South of the Dead Lake there is approximately a square mile of ground forested by coniferous trees, forming the pine association. Its present extent is much less than formerly. This is due to cutting, burning, erosion by the lake, and to natural successions. Of the three species of conifers that form the greater part of the association only one is nativ along the lake shore. This tree, Pinus strobus, was formerly relatively common but in now represented only by a few rather old trees in isolated situations. From the taxonomic natur of the other two species, Pinus laricio and Pinus silvestris, it is evident that they hav, at some past time, been planted there by man. It is difficult to secure accurate evidence as to the date, but it was probably sixty or seventy years ago. As long as the groves were taken care of the pines flurisht but with neglect and succession they are slowly yet surely disappearing.

Fysical and Ecological Characteristics.

The pine association occurs on sandy soil and especially on the

ridges of sand. Here for the first time there is a definite differentiation between the soil and the subsoil. Where the pines are densest there is a carpet of pine needles, which are gradually being converted into humus. The trees afford plenty of protection for ground plants but at the same time cut off so much light that ground plants occur only in the interstices between the trees and in places where a tree has been removed or cut, thus permitting more light to reach the ground. As a result of the ground covering, water is more easily retained and conditions in general are less xerophytic than those on the heath.

The Association.

This association is a representative of the boreal element which has remained as a relic of the postglacial coniferous forests which at one time were dominant in this region. In places where the pines are dense the association is more typical of its appearance in the northern regions. There are usually in such situations few or no secondary species. The exceptions are Smilacina stellata, Anemone cylindrica and Poa compressa. The ground is carpeted with needles and pine cones. In places where the association is more open, as along the ridges, there is an abundance of secondary species, all of which represent succeeding associations. Which association does follow is, of course, determined by the number and nature of the secondary species. In the ridges towards the southward, where the soil is more xerophytic, prairie plants surround the pine trees and often occupy the ground clear up to the trunk of the trees. In such places it is impossible for the pine to reproduce itself as their seeds cannot get down to the ground on account of the tangle of prairie grass, debris, etc. As long as the pine trees

liv they giv the character to the area but when they die the prairie dominates entirely. Toward the northward, altho there are many prairie species around the trees, there are plenty of young oaks, Quercus velutina, in all stages of development. They can grow quite easily and are able to replace the pine, not merely to dominate the region with the dying of the pines as is the case with the prairie plants. In the openings in the denser parts of the pine area the pioneer species that come in are forerunners of both the prairie and the oak forest. Seedling oaks are rather plentiful and occur at all distances from the parent trees, from which the acorns may be carried by birds, especially jays and crows. If the oaks are present in any number they determin which succession is to take place.

Pinus strobus, which is the only nativ of this region, occurs rather commonly thruout the association but it is rather more abundant in the more xerofytic and less fertil soils. It acts as a pioneer for this association and even now is very gradually reproducing itself on the edges of the prairie and marsh or in broken places in the prairie. This, however, is taking place much more slowly than the occupation of the pine land by the oaks. The densest growth of pine is formd largely of Pinus laricio and Pinus silvestris, growing in separate groves.

List of the Species of the Pine Forest Association.

- f Pinus strobus
- f Pinus laricio
- f Pinus silvestris
- f Larix laricina
- sr Juniperus (nana) *communis depressa*
- sr Juniperus horizontalis
- sr Arctostaphylos uva-ursi
- s Smilicina stellata
- s OEnothera rhombipetala

s *Anemone cylindrica*
 sr *Lithospermum gmelini*
 s *iPolygonatum commutatum*
 s *Aster azureus*

r *Elymus canadensis*
 r *Aster dumosus*
 r *Solidago nemoralis*
 r *Prunus pumila*
 r *Salix glaucophylla*
 r *Juncus balticus littoralis*
 r *Euphorbia corallata*
 r *Panicum virgatum*
 r *Artemisia caudata*
 r *Salix syrticola*
 r *Arabis lyrata*
 r *Sorghastrum nutans*
 r *Calamovilfa longifolia*
 r *Koeleria cristata*

invaders of the prairie.

i*Laciniaria scariosa*
 i*Potentilla fruticosa*
 i*Poa compressa*
 i*Poa pratensis*
 i*Trifolium hybridum*
 i*Plantago rugeli*
 i*Koellia virginiana*
 i*Taraxacum erythrospermum*
 i*Lobelia spicata*
 i*Clinopodium glabrum*
 i*Zizea aurea*
 i*Hypoxis hirsuta*
 i*Sisyrinchium sp*
 i*Equisetum laevigatum*
 i*Helianthemum majus*
 i*Phlox pilosa*
 i*Castilleja sessiliflora*
 i*Tradescantia reflexa*
 i*Comandra umbellata*
 i*Ceanothus ovatus*
 i*Epilobium densum*

invaders of the oak forest.

i*Fragaria virginiana*
 i*Rubus occidentalis*
 i*Verbascum thapsus*
 i*Rumex acetosella*
 i*Salix sp* ^
 i*Quercus velutina*
 i*Asparagus officinalis*
 i*Solidago serotina*
 i*Lonicera dioica*
 i*Vitis vulpina*
 i*Maianthemum canadense*

iLuzula campestris
 iHelianthus occidentalis illinoensis
 iCeanothus americanus
 iGeranium carolinianum
 iLactuca canadensis
 iRosa humilis

Quercus velutina Association.

As the climax stage of the successions on the ridges of this sand plain there exists this forest association. The association obtains its start in either of the prairie or coniferous associations, usually in broken places in them. It can obtain a slight foothold upon more or less open sand but it is more usually the case that the young oaks obtain their foothold in the humus of the prairie or the pines. Development then is quite certain but is rather rapid in the prairie situations. As development precedes the prairie gives way and after a time the ground begins to be more open and gradually the ground carpet disintegrates to a greater or less extent. Thereupon eremacausis, at least with respect to the upper layers of ground, begins again to be the usual state of affairs. This, coupled with the winds of the more violent storms, causes the surface to reassume a sandy appearance. The sand itself is more or less easily blown, especially where the removal of any of the trees permits a more open exposure. The results of such blowing is the formation of what are known as "blowouts". While the upper layers may be sandy and the secondary vegetation that of true sand ridges in which there had been no intervening prairie stage, the subsoil in which the oaks are rooted is distinctly humic in nature. The secondary species, however, consist of both prairie and sand plants, some of the latter of which, as Juncus balticus littoralis,

may hav persisted thru the prairie stage. The same thing happens with respect to the heath. As soon as the *Quercus* becomes dominant, light is cut off from the heath plants by its foliage and consequently the heath gradually givs way. With their disappearance the sand is left exposd to blowing. In such situations blowouts are very common. The invasion of the pines takes place much slower because that necessitates the dying of the old pine trees. These the oaks can not drive out as they can the herbaceous vegetation, but the young pines cannot germinate or develop under the shade of the oaks. This results in the extinction of the pines by the dying of the old trees. As soon as a pine dies the young oaks spring up all around it where they could not befor on account of the great shade from the pine. Once sufficient^{light} is allowd, the oaks very rapidly replace the spot with trees, against which invasion in this region the pines can do nothing.

The *Laciniaria scariosa* association may develop contemporaneously with the *Quercus velutina* but usually *L. scariosa* develops first and as it is a fairly open association the *Quercus velutina* quite redily invades it. This. association, however, will retain nearly all of its identity even after invasion because there is not as yet sufficient food material to support a dense growth of oak.. As soon as the oak does become dense the *L. scariosa*, also, givs way.

In its primary stages the *Quercus velutina* association occupies stable sandy soil where humification is the rule. The humus, however, is not abundant and consequently a luxurient undergrowth is not developt. Protection against wind and sun is afforded resulting in a flora somewhat mesofytic in tendency, as is shown in fig. 31.,



Fig. 31. *Quercus velutina* association near Zion City, Illinois, showing the structure of the vegetation. July 19 1909.

but the succession of this association to a distinctly mesofytic one requires a space of very many years. In the matur stages of the development of this association humification is very slow and may be absent. The oaks themselvs are well developt but their shade keeps out sand plants which would make a dense ground covering, while there is not sufficient food material in the soil to permit the growth of mesofytic forms which require the amount of shade that the oaks furnish. For these reasons, eremacausis again takes hold and very materially increases the length of time between this association and the one that will finally succede it.

Because of its great diversity of environments this association has a large number of secondary species, many of which belong more properly to other associations. The association itself is charac-

terized by the oak, Quercus velutina, as is shown in fig. 31. It is very seldom that other trees are found in the usual situations. The most frequent is the white pine, Pinus strobus, existing as a relic. A very few trees of Quercus macrocarpa and Quercus alba have been found in one locality.

List of the Species of the Quercus velutina Association.

f Quercus velutina

- s Acerates viridiflora
- s Achillea millefolium
- s Allium cernuum
- s Amorpha canescens
- s Anemone cylindrica
- r Andropogon furcatus
- r Andropogon scoparius
- s Antennaria sp
- s Apocynum androsaemifolium
- a Apios tuberosa
- s Aralia nudicaulis
- s Arabis lyrata
- r Arctostaphylos uva-ursi
- s Arenaria stricta
- r Artemisia caudata
- s Asclepias syriaca
- s Asclepias tuberosa
- s Asclepias incarnata
- s Asparagus officinalis
- s Aster azureus
- s Aster dumosus
- s Aster novae-angliae
- i Aster macrophyllus
- r Aster ptarmicoides
- s Aster sericeus
- s Betula alba papyrifera
- s Baptisia leucantha
- r Calamovilfa longifolia
- s Carex bebbii
- r Carex (gravidia ?)
- Catalpa speciosa
- s Ceanothus americanus
- r Ceanothus ovatus
- s Celastrus scandens
- s Chenopodium album
- a Cirsium arvense
- r Comandra umbellata
- s Convolvulus sepium
- s Coreopsis lanceolata
- s Coreopsis palmata
- a Cyperus rivularis.

- s *Desmodium illinoense*
- s *Epilobium angustifolium*
- s *Equisetum arvense*
- s *Erigeron canadensis*
- s *Erigeron ramosus*
- sr *Eryngium yuccifolium*
- s *Eupatorium purpureum maculatum*
- sr *Euphorbia corallata*
- s *Amphicarpa monoica*
- s *Fragaria virginiana*
- s *Geranium carolinianum*
- s *Gerardia grandiflora*
- s *Gerardia pedicularia*
- s *Helianthemum majus*
- s *Helianthus divaricatus*
- s *Helianthus grosseserratus*
- s *Helianthus occidentalis*
- s *Helianthus occidentalis illinoensis*
- s *Helianthus strumosus*
- s *Heuchera hispida*
- sr *Hypericum kalmianum*
- s *Hypericum* sp
 - r *Juncus balticus littoralis*
 - r *Juniperus communis depressa* (nana)
 - r *Juniperus horizontalis*
 - r *Koeleria cristata*
 - a *Krigia amplexicaulis*
- s *Lactuca canadensis*
- e *Lechea* sp
- s *Lespedeza capitata*
- sr *Liatris scariosa*
- ri *Liatris spicata*
- r *Lithospermum gmelini*
- s *Lobelia spicata*
- s *Lupinus perennis*
- s *Lepachys pinnata*
- s *Luzula campestris*
- Marchantia polymorpha*
- s *Monarda fistulosa*
- s *Monarda* sp
 - a moss
- s *Nepeta cataria*
- r *Oenothera rhombipetala*
- s *Oxypolis rigidior*
- s *Panicum scribnerianum*
- r *Panicum virgatum*
- r *Panicum* spp
- s *Pedicularis canadensis*
- r *Petalostemum candidum*
- r *Petalostemum purpureum*
- sri *Phleum pratense*
- s *Physalis virginiana*
- r *Pinus strobus*
- s *Plantago major*
- s i *Poa compressa*
- s *Poa pratensis*
- s *Polygala sanguinea*
- s *Polygala verticillata*

- s Polygonatum commutatum
- s Polygonum persicaria
- riPopulus deltoides
- riPopulus tremuloides
- s Potentilla arguta
- s Prenanthes alba
- s Prunella vulgaris
- sr Prunus serotina
- s Pteris aquilina
- sr Pycnanthemum virginianum
- f Quercus velutina
 - iQuercus alba (very, very few)
 - iQuercus macrocarpa (rare)
- s Rhus toxicodendron
- s Rosa humilis
- s Rosa blanda
- sr Rudbeckia hirta
- s Rudbeckia subtomentosa
- a Rynchospora capillacea leviseta
- r Salix glaucophylla
- r Salix longifolia
- r Salix pedicellaris
- r Salix
- r Salix
- s Sambucus canadensis
- s Scleria triglomerata
- s Scutellaria parvula
- s Silene antirrhina
- s Silene stellata
- s Silphium integrifolium
- s Sisymbrium officinale leiocarpum
- s Smilacina stellata
- s Smilax ecirrhata
- s Smilax hispida
- s Solanum nigrum
- s Solidago arguta
- s Solidago canadensis
- sr Solidago graminifolia
- r Solidago nemoralis
- s Solidago serotina
- s Spiraea salicifolia
- s Stipa spartea
- s Sanicula marilandica
- s Taraxacum erythrospermum
- s Tradescantia reflexa
- s Trifolium repens
- s Maianthemum canadense
- s Verbascum thapsus
- s Viburnum lentago
- s Vitis vulpina
- s Zizia aurea

Blowouts.

Blowouts are open sandy places evacuated by the wind. They may occur in almost any of the associations that inhabit sandy ground. They are usually started during the winter when the ground is not well protected by vegetation. Once started, however, any wind strong enough to move sand may effect their greater development. As a rule in this region vegetation is more than able to keep pace with any blowing that may take place and so there is but little blowout development during the growing season. Blowouts are especially liable to occur in the sand ridges no matter whether these are tenanted by the heath, the *Liatris scariosa* or the *Quercus velutina* associations. The blowouts of greatest extent occur in the *Quercus velutina* association, more especially where trees have been cut out. This is because the shade from the oaks has reduced the density of the vegetation underneath them and left more exposed surface to the wind. The largest of such blowouts is shown in fig. 7, page 10. In general the blowouts are elliptic to oval in shape with their major axis north-northeast or north-northwest. Occasionally a circular blowout may be found and less frequently crescent-shaped ones. Winds from all directions of the compass are responsible for blowouts of greater or less extent but the largest ones are formed by either the northwest or the northeast winds, either one of which is common and quite likely to be strong.

In some regions the flora of even quite widely separated blowouts is remarkably uniform but this can hardly be said to be true of this region. The blowout is in some measure dependent upon the surrounding association for most of its species, altho there are a few species which are characteristic of blowouts and which do not occur in immediately adjoining associations, as for example, Acera-

tes viridiflora lanceolata, Euphorbia corallata, Cyperus filiculmis, Sporobolus cryptandrus, Oenothera rhombipetala, Cyperus schweinitzii, Corispermum hyssopifolium and Monarda punctata. The blowouts occur in several associations, the association that succeeds the blowout need not be the same as the one in which it started. Blowouts occurring in the Quercus velutina association sooner or later give place to Quercus velutina but blowouts occurring in heaths may go to Quercus velutina, a thicket, Liatris scariosa, or to Liatris spicata. Blowouts in Liatris scariosa may go to Quercus velutina but more frequently to Liatris spicata and occasionally, when the blowing continues during the winter to near or below the Lake Michigan level, some of the marsh associations may replace it. Figures 32, 33, and 34 show some of these different types of blowouts.



Fig. 32. Blowout in Quercus velutina near Beach, Illinois. Revegetation consists largely of heath plants but scattered thruout are seedling Quercus velutina. July 19 1909.



Fig. 33. Blowout in the Heath Association near Zion City, Illinois. Revegetation by heath plants mainly. September 4 1909.



Fig. 34. Blowout on the edge of *Quercus velutina* near Beach, Illinois. Revegetation by prairie and marsh plants. September 11 1909.

List of the Species of the Blowouts.

- f Acerates viridiflora lanceolata
- f Euphorbia corallata
- f Cyperus filiculmis
- f Sporobolus cryptandrus
- f Oenothera rhombipetala
- f Cyperus schweinitzii
- f Corispermum hyssopifolium
- f Monarda punctata
- f Panicum virgatum
- f Koeleria cristata
- f Carex muhlenbergii
- f Rhus toxicodendron
- iQuercus velutina
- f Solidago nemoralis
- f Arctostaphylos uva-ursi
- f Smilacina stellata
- f Silene antirrhina
- f Andropogon scoparius
- f Scutellaria parvula
- f Lithospermum gmelini
- iLiatris scariosa
- iTradescantia reflexa
- riJuncus balticus littoralis
- iRosa humilis
- f Juniperus horizontalis
- f iArtemisia caudata
- iPoa compressa
- iPopulus deltoides
- iChenopodium album
- iHypericum kalmianum
- iSolidago serotina
- iAmorpha canescens
- iAsclepias tuberosa
- f Arenaria stricta
- iLithospermum angustifolium
- s Opuntia rafinesquii
- iSalix glaucophylla
- iMelilotus alba
- iPrunus pumila
- f Juniperus communis depressa
- iCalamovilfa longifolia
- a moss
- iJuncus torreyi
- f Cenchrus carolinianus
- iCakile edentula
- iAster ptarmicoides
- iAristida purpurascens
- iLiatris spicata
- iEleocharis intermedia
- iLobelia kalmii
- iPotentilla fruticosa
- iPolytrichum juniperinum
- iElymus canadensis.
- f Verbascum thapsus

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List of Species arranged in Systematic order
with collection numbers of those collected and the
names of the associations in which they occur in this
region.

(The order of Gray's Manual, 7th edition, is followed. Synonyms
that seem necessary to give are in parentheses)

THALLOPHYTA.

Chlamydomonas sp? - Chlamydomonas A.
Oscillatoria sp? - Chlamydomonas A.

BRYOPHYTA.

Marchantia polymorpha (3151) Quer. vel. A.
Polytrichum juniperinum (2744) edge of Quercus velutina A.

PTERIDOPHYTA.

Polypodiaceae
Pteris aquilinum L. Quercus velutina A.
Equisetaceae
Equisetum arvense L. incipient dune, Quercus velutina A. *Should be the middle dune.*
Equisetum hiemale L. (3041) Artemisia-Panicum A.
Equisetum laevigatum A.Br Pinus strobus A.

SPERMATOPHYTA.

Pinaceae
Pinus laricio Poir (2841.2903) Heath, Pinus strobus A.
Pinus silvestris L. (3165.3205) Heath, Pinus strobus A.
Pinus strobus L. (2483.2809.2905) Heath, Pinus stro., Quercus vel. A.
Larix laricina (DuRoi) Koch (2460.2842) Pinus strobus A.
Juniperus communis depressa Pursh (J. nana, Willd?) (1659.2843.2907.)
Juniperus dune, Bunchgr., Heath, Pinus stro., Quer vel., Blowout.
Juniperus horizontalis Moench (J. sabina L) (1658) Incipient dune,
Junip. dune, Art.-Pan., Bunchgr.; Heath, P. stro., Quer. vel., Blow.
Juniperus virginiana L (2910) Heath.

Juncaginaceae
Triglochin palustris L (2867) Trig. pal., Pot. anserina, Junc. balt. lit.

(Gramineae) Poaceae
Andropogon furcatus Muhl (2940) Bunchgr (Spor), Quer. velutina A.
Andropogon scoparius Michaux (2921) Calamovilfa, Salix syrticola,
Juniperus & Andropogon scop. dunes; Artemisia-Pan.; Bunchgr
(A. scop & Spor) Heath; Quercus velutina; Blowouts.
Sorghastrum nutans (L) Nash (2966) Bunchgr (Spor), Heath, Pinus stro.
Panicum capillare L (3232) stranded on beach
Panicum (? pseudopubescens?) (3224) Quer. vel., Blowout.
Panicum scribnerianum Nash (3065) Quercus velutina A.

- Panicum virgatum* L. (2938) Pot.anserina; Pop-Sal, Elymus, & *Panicum vir.* dunes; *Artemisia*-Pan; Bunchgr(Spor); Heath; *Pinus stro*; *Quer.vel*; blowout.
- Echinochloa crus-galli*(L)Beauv (3209) Trig.pal.
- Cenchrus carolinianus* Walt (2980) Stranded on Beach; relic dune; Pot.anserina; Blowout.
- Stipa spartea* Trin. (2464) *Quercus velutina* A.
- Aristida purpurascens* Poir. (3260) Blowout.
- Phleum pratense* L. (3064) *Quercus velutina* A.
- Sporobolus cryptandrus*(Torr)Gray. (3255) Relic dune; Pot.anserina; Elymus dune; *Artemisia*-Pan; Bunchgr(*Andropogon*, Spor); Blowout.
- Sporobolus heterolepis* Gray. (3223) Bunchgr(Spor).
- Calamovilfa longifolia*(Hook)Hack. (2920) incipient dune; Pot.anserina; *Calamovilfa*, *Ammophila*, *Salix syrticola*, *Prunus pumila*, *Juniperus*, *Populus-Salix*, *Andropogon scoparius* dunes; *Artemisia* *Panicum*; Bunchgr(*Andropogon*); Heath; *Pinus stro*; *Quercus velutina*; Blowout.
- Ammophila arenaria* (L)Link (3201.3281) *Ammophila* dune
- Koeleria cristata*(L)Pers. (2467.2763) Bunchgr(Spor); Heath; *Pinus stro*; *Quercus velutina*; Blowout.
- Spartina michauxiana* Hitchcock. (2913) Bunchgr(Spor).
- Poa compressa* L. (2860) incipient dune; *Panicum virgatum* dune; *Artemisia*-*Panicum*; Heath; *Pinus stro*; *Quercus vel*; Blowout.
- Poa pratensis* L. (3037, Stranded on the beach; P.v. dune; *Pinus strobus*; *Quercus velutina*.
- Elymus canadensis* L. (2879.2880) *Junc.balt.litt*; *Calamovilfa*, *Salix syrticola*, *Elymus*, *Populus-Salix*, and Manmade dunes; Bunchgr(*Andropogon*) *Pinus strobus*; Blowout.

Cyperaceae

- Cyperus filiculmis* Vahl.(3147) Blowout.
- Cyperus rivularis* Kunth. (2986) Trig.pal; *Quercus velutina*.
- Cyperus schweinitzii* Torrey. (3149) Blowout.
- Eleocharis intermedia*(Muhl)Shultes. (2926) Blowout to Prairie.
- Scirpus americanus* Pers. (2508.2856) Trig.pal; *Junc.balt.litt*.
- Rhynchospora capillacea leviseta* EJHill (2851.2925) *Quercus velutina* tho not characteristic of that association.
- Scleria triglomerata* Michaux. (2772) *Quercus velutina*.
- Carex bebbii* Olney. *Quercus velutina* A.
- Carex muhlenbergii*, Schk. (2465) Blowout.
- Carex grvida?* bailey. (3163) *Quercus velutina*. Blowout.

Commelinaceae

- Tradescantia reflexa* Rafinesque. (3022) *Pinus strobus*; *Quercus vel*; Blowout.

Juncaceae

- Juncus alpinus insignis* Fries. Trig.pal; Pot.anserina.
- Juncus balticus littoralis* Engelm. (2882.2923.3250) Trig.pal; *Juncus balt.litt*; relic dune; Pot.anserina; *Salix syrticola*, *Populus-Salix* and Manmade dunes; Bunchgr(*Andropogon*); Heath; *Pinus strobus*; *Quercus velutina*; Blowout.
- Juncus tenuis* Willd. Stranded on the beach.
- Juncus torreyi* Coville. (2869.2909) Trig.pal; Blowout.
- Luzula campestris*(L)DC. (3046) *Pinus strobus*, *Quercus velutina*.

Liliaceae

- Allium cernuum* Roth. (2895) *Quercus velutina*
Asparagus officinalis L. (3023) *Pinus strobus*, *Quercus velutina*.
 (*Smilacina stellata* (L)Desf)*Vagnera stellata*(L)Morong.(2492).
Pinus strobus, *Quercus velutina*, Blowout.
 (*Maianthemum canadense* Desf)*Unifolium canadense* (Desf)Greene.
 (2484.2488) *Pinus strobus*, *Quercus velutina*)
 (*Polygonatum commutatum*(R&S) Dietr.) *Salomonina commutata*(R&S)Britton.
 (3025) *Pinus strobus*, *Quercus velutina*.
Smilax ecirrhata(Engelm)Watson. *Quercus velutina*
Smilax hispida Muhl *Quercus velutina*.

Amaryllidaceae

- Hypoxis hirsuta*(L)Coville. (2519) *Pinus strobus*

Iridaceae

- Sisyrinchium* sp? (2485.2514.2855.3018) *Bunchgr*(*Andropog*),
Pinus strobus.

Salicaceae

- Salix glaucophylla* Bebb. (3033.3036) *Calamovilfa*, *Salix syrticola*,
Populus-Salix and Manmade dunes; *Bunchgr*(*Andropogon*); Heath;
Pinus strobus; *Quercus velutina*; Blowout.
Salix longifolia Muhl (S. interior, Rowlee) (3080) Stranded on
 middle beach; *Pot.anserina*; *Ammophila*, *Elymus*, *Salix syrticola*,
Populus-Salix, *Pop-Salix-Cornus* thicket, and Manmade dunes;
Bunchgr(*Andropogon*); *Quercus velutina*.
Salix pedicellaris Pursh (S.myrtilloides) (3174) *Quercus velutina*.
Salix syrticola Fernald (S.adenophylla) (2459.3156) *Junc.balt.litt*;
Pot.anserina; *Salix syrticola*, *Populus-Salix*, and *Panicum*
virgatum dunes; *Bunchgr*(*Andropogon*); Heath; *Pinus strobus*.
Populus candicans Aiton (2780.3155) Relic dune; *Calamovilfa*, *Prunus*
pumila and *Populus candicans* dunes; Heath.
Populus deltoides Marsh (3035) *Trig.pal*; *Junc.balt.litt*; *Pot.anser*;
Salix syrticola, *Populus-Salix* and *Pop-Sal-Cornus* thicket
 dunes; *Bunchgr*(*Andropogon*); Heath; *Quercus velutina*; Blowout.
Populus tremuloides Michaux (3104) *Quercus velutina*.

Betulaceae

- Betula alba papyrifera*(Marsh)Spach. (3097) *Quercus velutina*.

Fagaceae

- Quercus alba* L. (3125) *Quercus velutina* but not typical.
Quercus macrocarpa Michaux (3119) *Quercus velutina* but not typical)
Quercus velutina Lam (2981) *Calamovilfa* dune; *Bunchgr*(Spor);
 Heath; *Pinus strobus*; *Quercus velutina*; Blowout.

Santalaceae

- Comandra umbellata*(L)Nuttall (2790) *Bunchgr*(Spor); *Pinus strobus*;
Quercus velutina.

Polygonaceae

- Rumex acetosella* L. (3063) *Pinus strobus*.
 (*Polygonum lapathifolium* L)*Polygonum incarnatum* (3227) Stranded
 on the middle beach.
Polygonum persicaria L. (3253) Stranded on the middle beach;
Quercus velutina.

Polygonum acre H.B.K.(=P. punctatum Ell) (3241) Stranded on the middle beach.

Polygonum tenue, Michaux (3206) Bunchgr(Spor).

Chenopodiaceae

Cycloloma atriplicifolium (Spreng) Coulter (2975) Junc.balt.litt; Elymus dune; Artemisia-Panicum; Bunchgr(Andropogon).

Chenopodium album L. Quercus velutina; Blowout.

Corispermum hyssopifolium L. (3226) Blowout in Quer.vel.

Salsola kali tenuifolia GFW Mey(S.tragus) (2974) Relic dune.

Amaranthaceae

Acnida tuberculata subnuda Wats Stranded on the middle beach.

Caryophyllaceae

Arenaria stricta Michaux (2510) Artemisia-Panicum; Bunchgr(Andropo) Quercus velutina; Blowout.

Silene antirrhina L (2449) Quercus velutina, Blowout.

Silene stellata (L) Aiton f. (3267) Quercus velutina.

Anemone cylindrica Gray (2761) Bunchgr(Spor); Pinus strobus; Quer v.

Cakile edentula (Bigel) Hook (2976) Junc.balt.litt; Cakile-Xanthium; Elymus dune; Blowout.

Sisymbrium officinale leiocarpum DC. (3251) Quercus velutina.

Radicula palustris (L) Moench Stranded on the middle beach.

Arabis lyrata L (2511) Populus-Salix, Panicum virgatum, Andropogon scoparius artificial dunes; Artemisia-Panicum; Bunchgr(Andropogon); Pinus strobus; Quercus velutina.

Saxifragaceae

Heuchera hispida Pursh (1663.2451) Quercus velutina.

Rosaceae

Spiraea salicifolia L. (2888) Quercus velutina.

(*Pirus malus* L) *Malus malus* (L) Britton. Heath.

Fragaria virginiana Duchesne (2455.2480.2773) Stranded on the middle beach; Populus-Salix dune; Pinus strobus; Quer.v.

Potentilla arguta Pursh (Drymocallis a.) (2329). Bunchgr(Spor) Quer.v.

(*Potentilla*) *fruticosa* L. *Dasiphora fruticosa* (L) Rydb (2853.2973) Salix syrticola and Populus-Salix dunes; Artemisia-Pan; Bunchgr(Spor, Androp); Heath; Pinus strobus; Blowout.

(*Potentilla*) *anserina* L) *Argentina anserina* (L) Rydb. (2518.2924) incipient dune; stranded on the middle beach; Trig.pal; Junc.balt.litt; relic dune; Pot.anserina; Ammophila, Salix syrticola and Populus-Salix dunes.

Rubus occidentalis L. Pinus strobus

Rosa humilis Marsh. (3167) Pinus strobus, Quercus velutina; Blowout.

Rosa blanda Aiton (3262) Quercus velutina.

Prunus pumila L. (2458.2745) incipient dune; Calamovilfa, Ammophila, *Prunus pumila*, Populus candicans and Juniperus dunes; Artemisia-Panicum; Bunchgr(Andropogon); Heath, Pinus Strobus; Blowout.

Prunus serotina Ehrh (3028) Quercus velutina.

(Leguminosae) Papilionaceae

- Baptisia leucantha T & G (2750) Quercus velutina.
 Lupinus perennis L (2452) Quercus velutina.
 Trifolium hybridum L () Pinus strobus.
 Trifolium pratense L Stranded on the middle beach.
 Trifolium repens L. Stranded on the middle beach, Quercus velutina.
 Melilotus alba Desr. Populus-Salix dune; blowout.
 Amorpha canescens Pursh (2994) Bunchgr(Spor); Quercus vel; Blowout.
 Petalostemum candidum Michaux (2832.2871) Quercus velutina.
 Petalostemum purpureum(Vent) Rydb (2872.2922) Calamovilfa and Andropogon scoparius artificial dunes; Artemisia-Panicum; Bunchgr Andropogon); Heath; Quercus velutina.
 Desmodium illinoense Gray Quercus velutina
 Lespedeza capitata Michaux. (2962) Quercus velutina.
 Lathyrus maritimus (L) Bigel (3157) Ammophila and Salix syrticola dunes; Artemisia-Panicum.
 Apios tuberosa Moench. (2946) Quercus velutina.
 Amphicarpa monoica(L) Ell Quercus velutina.

Geraniaceae

- Geranium carolinianum L. (3152) Pinus strobus and Quercus velutina

Rutaceae

- Ptelea trifoliata L. (3229) Relic dune.

Polygalaceae

- Polygala sanguinea L(P.Viridescens L) (2948) Quercus velutina.
 Polygala verticillata L. (2983) Quercus velutina

Euphorbiaceae

- Euphorbia polygonifolia L. (2967) Cakile-Xanthium; Ammophila and Elymus dunes; Artemisia-Panicum.
 Euphorbia corollata L. (2852.2892) Elymus dune; Bunchgr(Spor, Andro) Pinus strobus; Quercus velutina; Blowout.

Anacardiaceae

- Rhus toxicodendron L (bushy form) (2506.2805) Elymus dune; Quercus velutina; Blowout.

Celastraceae

- Celastrus scandens L. Quercus velutina.

Balsaminaceae

- Impatiens biflora Walt. (2968) Populus-Salix dune.

Rhamnaceae

- Ceanothus americanus L. (3162) Heath; Pinus strobus; Quercus vel.
 Ceanothus ovatus Desf. (1656;2470.2812) Pinus strobus; Quercus v.

Vitaceae

- Pseodera quinquefolia (L)Greene Populus-Salix-Cornus thicket dune.
 Vitis vulpina L. (2930) Calamovilfa dune; Populus-Salix-Cornus thicket dune; Pinus strobus; Quercus velutina.

Hypericaceae

- Hypericum kalmianum L. (2462.2844) Bunchgr(Andropogon); Heath;
 Quercus velutina; Blowout.
 Hypericum sp Quercus velutina.

Cistaceae

- (Helianthemum majus B.S.P.) Helimium majus(L)Grosser (2752)
 Pinus strobus; Quercus velutina.
 Lechea (2889) Quercus velutina.

Cactaceae

- Opuntia rafinesquii Engelm (2302) Blowout.

Lythraceae

- Lythrum alatum Pursh. (3159) Stranded on the middle beach.

Onagraceae

- (Epilobium angustifolium L) Chamaenerion angustifolium (L)Scop.
 (2759) Quercus velutina
 Epilobium densum Raf. (2989.3236) Pinus strobus
 Oenothera biennis L Bunchgr(Andropogon)
 Oenothera rhombipetala Nuttall. (3158). Relic dune; Bunchgr(Androp)
 Pinus strobus; Quercus velutina; Blowout.

Araliaceae

- Aralia nudicaulis L Quercus velutina.

Umbelliferae

- Eryngium yuccifolium Michaux (2886) Quercus velutina.
 Sanicula marilandica L. (3021) Quercus velutina
 Zizia aurea (L)Koch (2476) Populus-Salix dune; Pinus strobus;
 Quercus velutina.
 Oxypolis rigidior(L)Coulter & Rose. (2934) Quercus velutina.

Cornaceae

- Cornus stolonifera Michaux. (2505.2757.3032) Relic dune; Prunus
 pumila and Juniperus dunes.

Ericaceae

- Arctostaphylos uva-ursi (L)Spreng. (2491) Juniperus dune; Artemisia-
 Panicum; Heath; Pinus strobus; Quercus velutina; Blowout.

Apocynaceae

- Apocynum androsaemifolium L. (3114) Quercus velutina.

Asclepiadaceae

- Asclepias incarnata L (2896) Quercus velutina.
 Asclepias tuberosa L (2781) Quercus velutina; Blowout.
 Asclepias syriaca L. (3088) Elymus dune; Quercus velutina
 Acerates viridiflora Ell Quercus velutina Blowouts
 Acerates viridiflora lanceolata (Ives)Gray. (2806.2808) Blowout.

Convolvulaceae

- Convolvulus sepium L. (3150) Quercus velutina.

Polemoniaceae

Phlox pilosa L. (2456) Pinus strobus.

Boraginaceae

Lithospermum angustifolium Michaux. (1655.3017) Blowout.

Lithospermum gmelini (Mx) A.S. Hitchcock. (2490.2776) Andropogon scoparius artificial dune; Artemisia-Panicum; Bunchgr (Andropogon) Pinus strobus; Quercus velutina; Blowout.

Verbenaceae

Verbena hastata L. (3211) Stranded on the middle beach.

Labiatae

Scutellaria parvula Michaux. (2461) Quercus velutina. Blowout.

Nepeta cataria L. (3136) Quercus velutina.

Prunella vulgaris L. Quercus velutina.

Monarda fistulosa L. (3168) Quercus velutina.

Monarda punctata L. (2939) Manmade dune; Blowout.

Satureja glabra (Nutt) Fernald (Clinopodium) (2788.2861) Pinus strobus.

Pycnanthemum virginianum (L) Dunal and Jackson (Koellia) (2874)

Pinus strobus; Quercus velutina.

Solanaceae

Solanum nigrum L. Quercus velutina

Physalis virginiana Mill. (2463) Quercus velutina.

Scrophulariaceae

Verbascum thapsus L. (3259, Stranded on the middle beach; Pinus strobus; Quercus velutina.

Linaria vulgaris Hill Manmade dune.

(Gerardia pedicularia L) Dasystema pedicularia Quercus velutina.

(Gerardia grandiflora Benth) Dasystema grandiflora Quercus vel.

Castilleja sessiliflora Pursh. (2466.2751.2811) Pinus strobus.

Pedicularis canadensis L. (2496) Pinus strobus; Quercus velutina.

Bignoniaceae

Catalpa speciosa Warder (3169) Quercus velutina.

Plantaginaceae

Plantago rugelii Dcne. Pinus strobus

Plantago major L. Quercus velutina

Caprifoliaceae

Lonicera dioica L. (2453) Pinus strobus

Viburnum lentago L. (3094) Quercus velutina

Sambucus canadensis L. (3116) Quercus velutina.

Lobeliaceae

Lobelia spicata Lam (2818) Bunchgr (Spor) Pinus strobus; Quer. vel.

Lobelia kalmii L. (2919) Blowout to prairie.

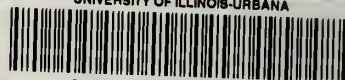
Compositae

- Eupatorium purpureum maculatum* (L) Darl. (2950) *Quercus velutina*.
 (*Liatris scariosa* Willd) *Laciniaria scariosa* (L) Hill. (2958)
Artemisia-Panicum; *Bunchgr*(Spor); Heath; *Pinus strobus*;
Quercus velutina; Blowout.
 (*Liatris spicata* (L) Willd) *Laciniaria spicata* (L) Kuntze. (2937.2928)
Quercus velutina; Blowout to prairie.
Solidago arguta Aiton. *Quercus velutina*.
Solidago canadensis L. *Quercus velutina*.
Solidago nemoralis Aiton. (3273) *Artemisia-Panicum*; *Bunchgr*(Spor,
Andropogon); Heath; *Pinus strobus*; *Quercus velutina*; Blowout.
Solidago rigida L. (3266) *Bunchgr*(Spor)
Solidago serotina Aiton. (2983) *Pinus strobus*; *Quercus velutina*;
 Blowout.
Solidago speciosa angustata T&G (3265) *Bunchgr*(Spor);
 (*Solidago graminifolia* (L) Salisb) *Euthamia graminifolia* (3233)
Ammophila and *Salix syrticola* dunes; *Quercus velutina*.
Aster azureus Lindl. (3268) Heath; *Pinus strobus*; *Quercus velutina*
Aster dumosus L. (3208.3221) *Artemisia-Panicum*; *Pinus strobus*; *Quer.v.*
Aster macrophyllus L. (3128) *Quercus velutina*
Aster multiflorus Aiton. (3164) *Bunchgr*(*Andropogon*).
Aster novae-angliae L. (3263) *Quercus velutina*
Aster ptarmicoides T&G (2957.2944) *Bunchgr*(Spor); Heath; *Quercus*
velutina; Blowout.
Aster sericeus Vent. (3154) *Quercus velutina*.
Erigeron ramosus (Walt) B.S.P. (3090) *Quercus velutina*.
Erigeron philadelphicus L. (3020) *Populus-Salix* dune.
 (*Erigeron canadensis* L) *Leptilon canadense* (L) Britton. (3256) *Quer-*
cus velutina.
Silphium integrifolium Michaux. (2893) *Quercus velutina*.
Xanthium commune Britton. (3228) Incipient dune; *Cakile-Xanthium*;
Ammophila and *Salix syrticola* dunes.
Rudbeckia hirta L. (2830) *Quercus velutina*.
Rudbeckia subtomentosa Pursh. (2890) *Quercus velutina*.
Lepachys pinnata (Vent) T&G (*Ratibida*) (2891) *Quercus velutina*.
Helianthus divaricatus L. (2954) *Quercus velutina*.
Helianthus grosseserratus Martens. *Quercus velutina*.
Helianthus occidentalis Riddell (2965) *Pinus stobus*; *Quercus velut.*
Helianthus occidentalis illinoensis (Gleason) Gates. (2774.2887.
 2936) *Quercus velutina*.
Helianthus strumosus L. *Quercus velutina*.
Coreopsis lanceolata L. (2478) *Quercus velutina*.
Coreopsis plamata Nuttall. (3148) *Quercus velutina*.
Achillea millefolium L. (2760) Manmade dune; *Quercus velutina*.
Artemisia caudata Michaux (2972) *Elymus*, *Populus-Salix* and Manmade
 dunes; *Artemisia-Panicum*; *Bunchgr*(*Andropogon*); Heath;
Pinus strobus; *Quercus velutina*; Blowout.
Cirsium arvense (L) Scop (3245) Stranded in the middle beach;
 Relic dune; *Quercus velutina*.
Cirsium pitcheri (Torr) T&G. (2866) *Artemisia-Panicum*.
Krigia amplexicaulis Nuttall (*Adopogon virginicum* (L) Kuntze) (2499)
Quercus velutina.
Taraxacum erythrospermum Andrez. *Populus-Salix* dune; *Pinus*
strobus; *Quercus velutina*.
Lactuca canadensis L. *Pinus strobus*; *Quercus velutina*.
Prenanthes alba L (*Nabalus albus*) *Quercus velutina*.





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